PART 1

THE STRATEGIC CONTEXT OF EDUCATION IN AMERICA

2000 to 2020

by

David Pearce Snyder, Gregg Edwards and Chris Folsom

Consulting Futurists

Published in *On the Horizon,*

Volume 10, Number 2 2002, Volume 11, Number 1 2003

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

The Strategic Context of Education in America
2000 to 2020

TABLE OF CONTENTS

INTRODUCTION 4

The Random Future – 9/11 and Other "Wild Cards" 5
- Weather and Politics 5
- Markets and Marketplaces 5
- Accidental Discoveries and Unexpected Breakthroughs 6

THE KNOWABLE FUTURE – BENCHMARKS FOR STRATEGY 8
- The Demographic Context of Education – 2000 to 2015 8
- The Economic Context of Education – 2000 to 2010 12
- The Technologic Context of Education – 1946 to 2020 15

NEW SOCIAL TECHNOLOGY 16
- Outsourcing Information Overload 17
- From Vertical Integration to Virtual Integration 18
- Outsourcing Schools 19
- Old Schools for the New Century? 20
- Outsourcing Classes 22

NEW PHYSICAL TECHNOLOGY 23
- Broadband: The High Speed Internet 24
- "Frictionless Commerce" 24
- "Info-mated" Equipment 25
- Distributed Computing 25
- The best laid plans, etc., etc 26

GETTING HI-TECH BACK IN HIGH GEAR 27
- "Wi-Fi" to the Rescue! 28
- Linux 29
- Software Wars 31
- Groupware 32
- Conversational Computing 35

ON THE THRESHOLD OF …. ? 37
- Long-Term Vision for a Short-Term World 38

REFERENCES 39

INTRODUCTION

As is true for the leadership of any other business or profession, the superintendents, deans, principals, union officials, and board members who lead education should be familiar with the reliably-forecastable realities that will be prominent features of their institutions' future operating environment. In fact, the relevance of the future to education transcends its relevance to other enterprises, since education is ***about*** the future. The primary purpose of schooling is to prepare people – collectively and individually – to deal with the daily tasks and the longer-term imperatives and opportunities that they will encounter in their future lives. Thus, significant projected changes in education's future operating environment would require school leaders to plan not only for changes in how much education will be needed and how education will be delivered, but also for changes in the content of education itself.

Of course, the future seems much less certain now than it did two or three years ago, when everything was "coming up roses." The dot.com bust, terrorist attacks and massive corporate malfeasance have dispersed many of our casual assumptions about the future. Economic forecasts have become less confident and more ambiguous. While some experts have concluded that the high tech boom was a flash in the pan, others argue that a bigger boom is yet to come. All of this is duly reported, analyzed, and debated in the media, and the resulting cacophony in the public policy arena is obscuring the reliably forecastable long-term realities that we can be reasonably certain will reshape daily life and work and in America during the decade ahead. And, because addressing these realities will be instrumental to the success of education – and thus, the success of the nation – it is particularly important at this turbulent and uncertain moment for educators to reflect upon what we know about the long-term future.

The Random Future – 9/11 and Other "Wild Cards"

Suicidal sky-jackings and anthrax in our mail have led some people to ask, "In a world where apparently ANYTHING can happen, can anything about the future be certain?" To this legitimate question, the futurist must concede that many of the "surface features" of the future – including dramatic events and dynamic personalities – occur randomly over time, and cannot be reliably forecast. Some of the more prominent random features of the future include political actions, stock market behavior, economic performance, scientific breakthroughs and the weather.

Weather and Politics

While great strides have been made in improving short-term weather forecasts **and** in predicting voter behavior, unexpected weather and election upsets still occur routinely. Forecasting **either** the long-term atmospheric **or** political climate remains problematic at best. Our inability to reliably forecast long-term climate change is the principal reason why we have been unable to reach a political consensus on global warming. The long-term non-predictability of politics means that educators should not casually assume that the nation's past commitment to publicly-funded education will continue unabated, or that political initiatives will not dramatically alter the economics, the markets, the missions, the organizational structure, the curriculum content and the technology of educational institutions over the next five to ten years. Politics will remain as unpredictable in the future as it has been in the past, . . . perhaps even more so.

Markets and Marketplaces

Similarly, educators – and those who manage their pensions and endowments – should not base crucial long-range decisions on assumptions about the future performance of the stock market. As statisticians have repeatedly demonstrated, all stock markets are "random walks" whose behavior is not reliably forecastable from hour to hour, let alone from one year to the next. One-third of post-secondary trusts and endowments are invested in stocks, and among the larger private schools, the end of the ten-year bull market has reportedly reduced the value of those funds by hundreds of millions of dollars. And, since most institutions disperse roughly 5% of their endowments each year to underwrite student grants and subsidize campus operations, shrinking endowments are causing tuition increases, hiring freezes, cuts in student aid and project/program delays and cancellations (Zhao 2002).

Not only can we **not** reliably forecast how soon our endowments will regain their lost value, we can only guess at when the U.S. economy will emerge from the current economic slow-down. The Business Cycle Dating Committee of the National Bureau of Economic Research didn't decide until November 2001, that the U.S. had actually entered a recession eight months *earlier*, in March 2001. Of course, according to the classic definition, a "recession" involves at least two consecutive calendar quarters of shrinkage in the GDP. And, while the U.S. economy **did** shrink by .2% in the third quarter of 2001, it actually grew at a 1.7% annual rate during the fourth quarter, the fastest rate in over a year. Although some economists believe that the economy will resume shrinking later in 2002 – called a "double-dip" recession – the Federal Reserve Chairman has pronounced that the shortest recession in history is already over, and the Treasury Secretary, Paul O'Neill, has concluded that there wasn't any recession at all!

In short, there is no reliable means by which we can forecast changes in the performance of the economy. Economists predicted NONE of the ten U.S. recessions or three U.S. "booms" since WWII. This means that economists can offer little insight into how soon public educators can expect robust local economies to increase the flow of tax revenues to public schools. They are even less able to inform judgments concerning how soon recent declines in alumni donations might be reversed, since such largess is linked to the performance of **both** the stock market **and** the economy. And, for students approaching graduation, economists can make no reliable assertions with respect to when the job market will pick up.

Accidental Discoveries and Unexpected Breakthroughs

One last random component of the future that holds particular relevance for higher education is the pace and direction of scientific progress. We have no reliable means of forecasting the timing of specific scientific breakthroughs. How soon will we have a cure for Alzheimer's? When will we achieve sustained fusion? Maybe next week; maybe next century! Even in carefully designed research projects, most breakthrough discoveries are unintentional. As the late Herb Simon observed, "If you look at the Nobel Laureates, in case after case after case, the critical event was a surprise." Kevin Dunbar, a researcher at McGill University's Cognitive Neuroscience Center, had investigators look over the shoulders of scientists at eight North American biological research labs for two years. He found that 50% to 60% of all experimental results did not support the hypothesis that went into the design of the experiment, and that 50% to 70% of scientists' conclusions arose from unexpected results (Weiss 1998).

In spite of the unpredictability of scientific research, the economic benefits of breakthrough discoveries are so enormous that America spends more than a quarter $trillion a year on R&D, including nearly $40 billion annually on basic scientific research, over half of which is conducted by colleges and universities. In 2000, the total research activities of U.S. colleges and universities involved expenditures of $36 billion, roughly 15% of the total operating budgets for all four-year institutions nation-wide. Post-secondary institutions themselves underwrite less than one-fourth of their research, receiving the bulk of their funding – $20 billion in 2000 – from Federal agencies or state and local governments.

Research is integral to both the classical and modern definitions of higher education. In theory, faculty maintain currency and fluency in what they teach by spending time probing the frontiers of knowledge in their fields. In fact, Daniel Rock, at the Educational Testing Service, has found that a distinguishing characteristic of demonstrably superior post-secondary academic programs is "student involvement in faculty projects" and "extra lab time." And, since economic research has demonstrated that more than half of the historic growth in U.S. per capita income is attributable to advances in technology (Cohen, Noll 1994), it would seem reasonable to assume that the public sector will continue to underwrite the nation's investment in basic research. *But such an assumption would constitute a political forecast, and as such, must be regarded as risky.*

In the mid-1950s, Federal expenditures represented two-thirds of the Nation's total annual investment in R&D. After Sputnik (1958), business expenditures on R&D rose steadily, matching Federal outlays by the mid-1970s and rising in tandem until 1990, when both government and industry were each investing about $65 billion p.a. on research. But since 1990, annual business investments in R&D have nearly tripled, to $180 billion, while the Federal research budget has remained essentially unchanged, and has actually dropped 5% in constant dollar terms. Historically, war has always provoked an increase in R&D, and by January of this year, Federal agencies had announced over $2 billion in new anti-terrorism research. Both the Department of Health and Human Services and the Pentagon have issued wide-ranging invitations for research proposals. And John Marburger, recently confirmed as President Bush's science advisor, reports receiving a "huge, spontaneous outpouring of concepts and ideas," ranging from new ways to protect buildings, power lines and reservoirs to advanced systems for detecting chemical weapons and other bio-terror agents, and for maintaining cyber-security (Hayden 2002).

Unfortunately, owing to current fiscal constraints, any new anti-terror research is likely to be funded by resources diverted from other research. Meanwhile, last fall (10/26/01), Congress passed the "Patriot Act," which restricts researchers' access to thirty-six potential bio-terror agents. Additional legislation now pending in Congress would prevent foreign nationals from working with dangerous microbes, would bar publication of genetic research data and even ban publication of all research on what makes specific microbes dangerous. Such impediments, plus other recent and proposed restrictions on Federally-funded research regarding stem cells, cloning, etc., all threaten to drive much academically-centered research into the private sector. And there are some who believe that would be a good idea.

In 1996, the University of Rhode Island released a comprehensive study of their own income and outlays, which showed that it costs the University more to get grants and administer research projects than the grants actually pay, leading to a negative cash flow that is made up by the students in the form of tuition increases. Without the operating losses arising from the University of Rhode Island's tens of $millions in yearly research grants, the study concluded, average tuition could have been cut by $1,900, from $4,400 to $2,500. The *Chicago Tribune* has also reported that the preliminary findings of an audit of finances at the University of Michigan "seemed to show that the tuition checks of its students help bail out research programs that run in the red." This followed a previous study of tuition inflation over the prior nine years that concluded that, "the rise in student fees has not been matched by any commensurate rise in expenditures on instruction or on student service support activities" (Grossman, Leroux 1996).

After a decade during which tuitions rose more than twice as fast as the Consumer Price Index, the continued underfunding of university research and the legitimate relationship of R&D to higher education are both likely to be politically and economically problematic issues for academia in the decade ahead.

THE KNOWABLE FUTURE – BENCHMARKS FOR STRATEGY

The futurist can afford to concede the unpredictability of the foregoing random phenomenon – and many others – largely because history strongly suggests that such factors do not ***alter*** the long-term course of human progress. However, they can – and do – speed up or retard the existing long-term forces of change. The long-term forces for change – i.e., those that we can reliably forecast some useful distance into the future – include:

1. The size and make-up of the adult population;
2. The composition of the economy and the job market;
3. The characteristics and capabilities of mass-market technologies.

Together, these three sets of forecastable realities are the principal features of the "knowable future"; they constitute the reasonable certainties upon which sound strategies can be built.

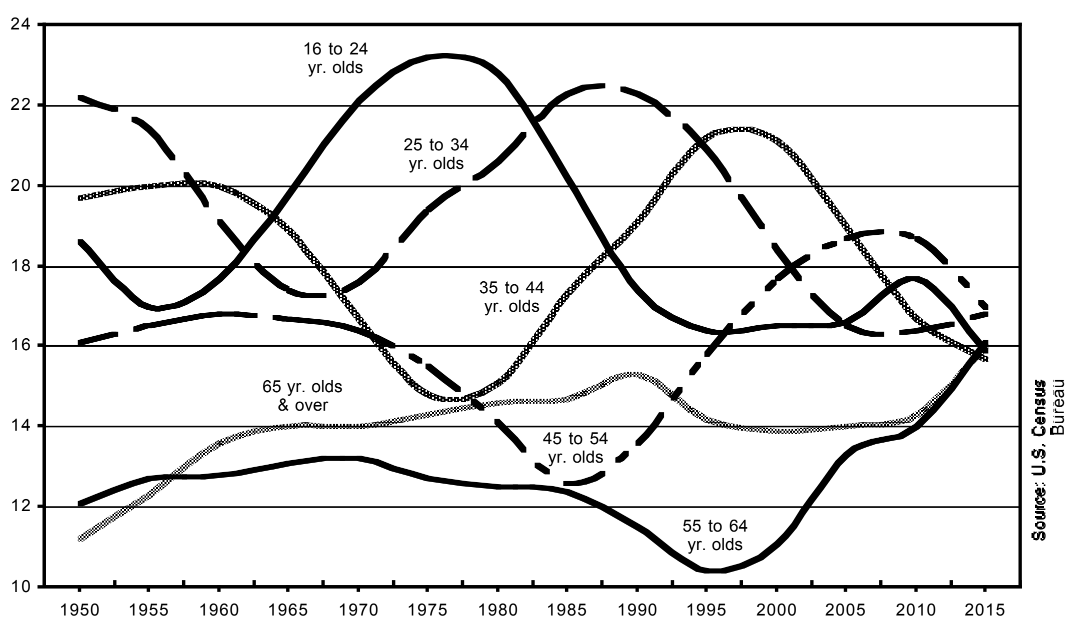
The Demographic Context of Education – 2000 to 2015

The basic function of education is human resource development, and we know a great deal about the future of human resources in America. To begin with, we can be reasonably certain that there are going to be a lot more Americans in the future; the Census Bureau expects the U.S. population to double during the 21st Century – from 287 million today to 571 million by 2100. In consonance with that growth, the Department of Education projects K-12 school enrollment will rise from a record 53 million today to 94 million by Century's end. At the other end of the age distribution, the number of people over the age of sixty-five – numbering 34 million today – is expected to reach 131 million by the end of the Century, making them nearly one-quarter of all Americans. And, as the population grows older, it will also become much more diverse. By 2100, Euro-descended Americans are expected to make up just 40% of the total U.S. population; Hispanics will constitute 33%, while African- and Asian-Americans will each account for 13% (El Nasser 2002).

To be sure, 100-year population forecasts are subject to considerable potential variability, and must be regarded as *reasonable probabilities* rather than certainties. As such, they cannot, strictly speaking, be regarded as part of the "knowable" future. Such long-term projections are, however, entirely valid indicators of where the American national enterprise is headed, and their implications are awesome. Twice as many Americans will require twice as much infrastructure as today. Twice as much suburban sprawl! Twice as many teachers and classrooms! Fortunately, this huge future is far enough distant in time that it need not concern us for the moment. Even more fortunately, for the nearer term future – i.e., the next fifteen years – demographers can provide all institutional leaders – including those in education – with reliable, detailed information about their changing human resource environment.

It is possible to make precise, consistently reliable forecasts of the size and makeup of the adult population for the next fifteen years simply because all of the people who will become adults during the next fifteen years have already been born. This means we know exactly what our labor force and our consumer markets will be like through 2015, by age, race and gender, etc. FIGURE 1 displays the changing age make-up of the U.S. adult population from 1950 to 2015. At a glance, it is clear that, at least in one respect, American society is about to become fundamentally different from what it has been for the past fifty years.

(Fig. 1) AGE COMPOSITION OF THE U.S. ADULT POPULATION 1950-2015



The "roller coaster" changes in age distribution that have characterized American society over the past half century are the direct result of adaptive social behavior. During the austerity and uncertainty of the Great Depression and the Second World War – 1930 to 1945 – U.S. birthrates temporarily dropped one-third below average long-term levels. This "Birth Dearth" was immediately followed by the more famous "Baby Boom" – 1946 to 1964 – as fertility rates returned to long-term norms once peace and prosperity had been restored. The rolling disparities in our population age mix arising from society's adaptive behavior has given the Baby Boomers unusual leverage in the consumer marketplace and in the voting booth.

In the forty years since the Boomers entered the U.S. adult population, they have represented 50% to 100% more people than any other age group in society. As a consequence, the Boomers have not only dominated our tastes in food, clothing, music and life-styles, but their values were instrumental in forging the political consensus that gave us the watershed progressive legislation of the 1960s and 1970s: e.g., the Civil Rights Act, the Environmental and Consumer Protection Acts, the Occupational Safety and Health Act, and the Freedom of Information and Privacy Protection Acts. Hundreds of thousands of 16- to 24-year-old Boomers, mobilized in the streets and at the polls, were the surrogates of the national consensus that coerced America out of Vietnam.

The creation of the U.S. Department of Education (1979-81) was perhaps the last noteworthy political consequence of the Boomer consensus. Of course, since Baby Boomers remain the single largest age group of adult Americans, they may yet again mobilize in support of one or more issues to evoke a new national political consensus. (Political observers have long predicted that the Boomers will not take the institutional indignities of old age "lying down.") But by 2015, the Baby Boom's political leverage will have dramatically diminished, their huge numbers off-set by their own maturing children and the rising tide of over-65-year-olds. By 2015, each of the six major age groups will constitute roughly one-sixth of all U.S. adults: between 15.8% and 17% of the total.

Social demographers have suggested that, with each age cohort representing a roughly equivalent share of the U.S. electorate, it will be more difficult to forge political consensus in the future than it has been in the past, especially with respect to the allocation of taxes and public funds. The producers of mass-market goods and services commonly expect that selling to a marketplace where there is no dominant, trend-setting age group will be much more challenging than marketing in the Baby Boom Era. And the labor-intensive components of our economy, including healthcare, the military and education, will find that, while the supply of entry-level workers – 16 to 24-year-olds – will increase very slowly over the next fifteen years, the numbers of employees of retirement age – 55 to 64 year-olds – will soar by more than 50%.

The Bureau of Labor Statistics (BLS) has projected that, between 1998 and 2008, 22.5% of all elementary school teachers (418,000), 30.5% of all secondary school teachers (378,000) and 15.0% of all college and university professors (195,000) will enter the 55- to 64-year-old age group, in which over 85% of all Americans retire. This will also be true for 178,000 education administrators, accounting for almost 40% of their ranks! Over the next ten to fifteen years, as the Boomers reach retirement age, every sector of the U.S. economy expects to experience a similar exodus. The replacements for these retiring millions will be recruited largely from the Baby Boom Echo.

The Baby Boom Echo, which began in 1981, has already lasted longer than the original Boom (1946-1964), and has produced more babies (82 million vs. 78 million). What's more, the Echo Boom isn't over yet! Baby Boomer birth rates peaked in the early 1990s, and had begun falling when the renewed prosperity of the late 1990s inspired a second round of child-bearing among younger boomer households (35- to 44-year-olds). Currently, U.S. birthrates are at a thirty-year high, which accounts for today's burgeoning school enrollments.

During the next ten years, however, as the Boomers pass out of their child-bearing years, they will be supplanted by the offspring of the smaller "Baby Bust" cohort (born between 1965 and 1980), which will cause birthrates to moderate. Meanwhile, although the Echo Boom will produce substantially greater numbers of new Americans than did the original Boom, the U.S. population has grown so much since the 1960s that the Echo Boom will cause only a modest, temporary increase in the 16- to-24-year-old share of our total population. (See FIGURE 1) The original Baby Boom boosted U.S. population by 44%; the Echo Boom is likely to add only 30% to the number of Americans.

The "good news" to be inferred from this reality is that we are **not** going to have to live through a repeat of the turbulent 1960s and '70s, when nearly one-fourth of the adult population were immature idealists on testosterone. The bad news is that, unlike the 1960s and '70s, when the Baby Boom made labor plentiful and cheap, the numbers of Echo Boomers will be insufficient to fill **both** the vacancies created by their parents' retirement **and** the new jobs that will be created by the growth of our economy. For education, training and library occupations, the BLS forecasts that, in addition to the nearly 1.76 million retiring personnel who will have to be replaced over the next ten years, it will also be necessary to recruit another 1.57 million faculty and staff to fill the new positions created to meet the learning needs of our growing society and economy.

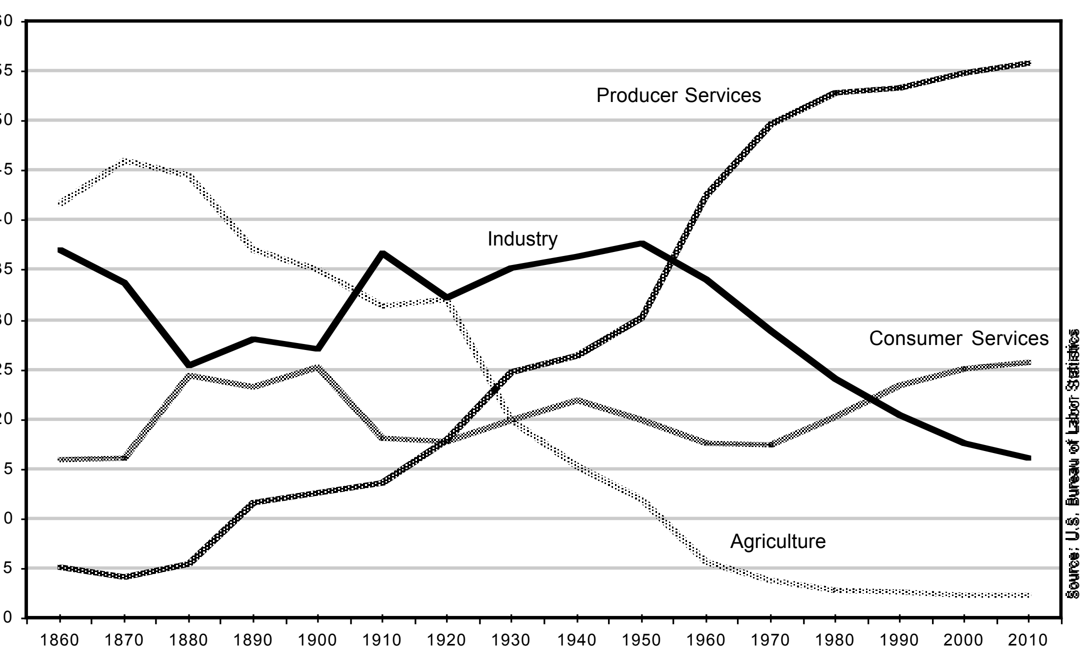
The demographic realities of the next decade-and-a-half will confront education and other labor-intensive components of our economy – healthcare, construction, consumer services, the military, etc. – with serious, unignorable human resource supply problems.

The Economic Context of Education – 2000 to 2010

The BLS forecasts the future size and make-up of the economy by assuming that each additional American will, on the average, consume the same amounts of private- and public-sector goods and services that the average citizen consumes today. This permits the Labor Department's statisticians to extrapolate the probable size and make-up of the U.S. economy on the basis of the Census Bureau's highly reliable population forecasts. Over the past half-century, the BLS's moving 10-year forecasts of the composition of the U.S. economy and job market have proven remarkably accurate.

FIGURE 2 shows the long-term evolution of the U.S. workforce since 1860, projected through 2010. The coming decade will see the continued growth of Producer Services as the dominant employer in the U.S. economy, with over 55% of all workers engaged in professional, managerial, technical, supervisory or other information-intensive work. The combined numbers of people directly involved in the physical production of food, material, infrastructure and manufactured goods dropped below 20% of the total U.S. workforce for the first time ever during the 1990s, and will continue to decline. Meanwhile, consumer services today employ 25% of U.S. workers for the first time in one hundred years, and their share of total employment is expected to grow.

(Fig. 2) FOUR SECTORS OF THE U.S. WORKFORCE 1860-2010



Because the effective development and use of our human resources are intrinsic to the long-term success of the Nation, the Federal government publishes detailed, long-range projections of the supply of – and demand for – labor, to help employers, educators and individuals prepare for the future. Forecasts for the specific numbers of positions to be added to – or subtracted from – each type of job in America for the next ten years are posted at the BLS Website: http://www.bls.gov/home.htm For those occupations that are projected to gain the largest numbers of new positions, the BLS also publishes the median U.S. income for each such job and the typical educational requirements of the position.

Overall, the BLS forecasts that total employment in the U.S. will rise from 145.6 million in 2000 to 167.8 million in 2010. By comparison, the U.S. workforce is projected to grow from 140.9 million in 2000 to 157.7 million by 2010. This means that the current 4.7 million shortfall of qualified recruits for advertised positions – including many jobs in education – will become a **10 million** worker shortage by 2010! While the labor force will only grow by 12% (16.8 million workers) during the current decade, the number of jobs is projected to grow 15.2% (22.2 million jobs). The BLS forecasts employment in education to rise by 19%, while employment in healthcare is expected to rise 25%, and by 26% among all other professional, managerial and technical fields. The existing shortage of workers is being met through a variety of expediencies, including overtime, part-time employment, increased workloads, reduced performance standards, and the use of unqualified personnel. But employment experts believe that a doubling of the current labor shortage will almost certainly provoke wage inflation and jeopardize our future economic growth (Francese 2002).

Certainly, a doubling of the current workforce shortfall will jeopardize the future of the current, labor-intensive U.S. system of education. The U.S. Department of Education (DOE) estimates that, as a result of existing shortages of qualified recruits, over one-fourth of recently-hired teachers do not fully meet state certification standards, and are teaching on temporary, provisional or "emergency" licenses. Nearly 28% of all U.S. teachers, according to the DOE, have neither a college major nor minor in the subjects they teach (Perlstein 1998). The National Commission on Teaching and America's Future reports that more than 12% of all newly-hired teachers – mostly transfers from other occupations – enter the classroom *without any teacher training at all* (Kantrowitz, Wingert 2000). In many localities, student-teacher ratios substantially exceed national standards, and some large urban school districts began recruiting teachers from Europe, Africa, India and the Philippines. Higher education, meanwhile, has dealt with the instructor shortfall largely by hiring part-time instructors, who now make up over 40% of the faculty at all U.S. post-secondary institutions (Marklein 1999).

An Untenable Future!

Together, the two most reliably forecastable realities of the next ten years – the labor supply and the job market – confront American education with an untenable future. Just to maintain current levels of service, U.S. educational institutions will collectively have to hire 3.4 million replacement and expansion personnel during the coming decade. This means that education will need to hire 20% of the 16.8 million young adults who will enter the labor pool during the next ten years. BLS projects the supply of K-12 teachers will need to grow 16.6% during the current decade to meet replacement and growth demands, while the numbers of post-secondary faculty will have to increase 23.5%. But the American Association of Colleges of Teacher Education expects the supply of teachers in America to grow by only 3.6% between 1998 and 2004, and by just 1.2% from 2005 through the end of the decade (Kantrowitz, Wingert 2002).

Public sector agencies – including large school districts – have reported an up-turn in recruitment in recent months, fueled by people who say that the 9/11 terrorist attacks made them rethink life and decide to pursue more meaningful careers. Programs throughout the U.S. that help career-changers become teachers have reported 200% to 400% increases in "expressions of interest" (Goodnough 2002). However, while event-induced changes in marketplace behavior are a well-documented phenomenon, their effect is generally not long-lasting. The fact is that there will be insufficient human resources to meet the projected personnel requirements for our labor-intensive educational institutions. Even raising faculty salaries will not solve the problem, because there will be an absolute short-fall of warm bodies in the labor market to fully staff today's schools and colleges to meet the educational requirements of the coming decade.

Already understaffed, educators must continue to provide their essential services to a steadily growing number of students with the very real prospect of losing more staff to retirement each year than can be fully replaced through new recruits. What's more, the nation's K-12 faculty and administrators are about to be saddled with the un-funded testing provisions of the National Elementary and Secondary Education Act. The relative educational merits of the new national testing regimen aside, most of the substantial resources that will be needed to implement annual testing and meet new academic standards are likely to be diverted from school technology budgets. Ironically, technology offers the principal means by which the nation's schools can purposefully address the educational imperatives implicit in the demographic and economic realities of our knowable future.

The Technologic Context of Education – 1946 to 2020

New mass-market technology is the third major component of the reliably forecastable future, and during the next two decades, new technology will be the most dynamic and highly leveraged component of the 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 shaping long-term 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 underlying long-term 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 2 decades. What's more, it is now clear that information technology (IT), in particular, will offer educators the means by which to fulfill all of their basic functions in spite of the challenges posed by our impending demographic and economic circumstances.

Readers will be more than justified in responding skeptically to our assertion of an impending technology-driven transformation of education – or any other institution. It has, after all, been over 56 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 have lived through more failed info-system projects than successful ones. But economic historians tell us that new technologies don't become reliable, affordable and truly 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," U.S. annual productivity improvement rates doubled, and have remained at that higher rate since, after having stagnated for 20 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 reported that "We can now see computers in the productivity statistics" (Uchitelle 2000).

More importantly, over the past 5 to 10 years, we have begun to understand exactly how successful early-adopters have employed IT to become substantially more productive than their competitors. A 1995 joint survey by the Harvard and Wharton business schools with the Ernst & Young Center for Business and Innovation reviewed the results of over one hundred studies of business practices and found that, "Economic benefits to companies were greatest when they successfully integrated innovations in management and technology with appropriate employee training and 'empowerment' programs" (Investment 1995). A similar 2001 survey by the Organization for Economic Cooperation and Development (OECD) concluded that, "Organizational change, understood as the implementation of new work practices such as teamwork, flatter management structures and job rotation, tends to be associated with higher productivity growth. Interestingly, productivity gains of firms that combine new technology with organizational change are considerable, whereas there does not appear to be much economic benefit from implementing new technology alone" (Taylor 2001).

Based on a 5-year study of data gathered from 1,167 large companies in 41 industries, Erik Brynjolfsson (MIT) and Shinkyu Yang (NYU) have found considerable evidence to demonstrate that the direct costs and benefits of computers represent no more than the fractional tip of a "much larger iceberg of complementary organizational, process and strategic changes" (Brynjolfsson, Yang 2001). Brynjolfsson estimates that, in order to actually reduce labor requirements and increase total factor productivity, for every dollar spent on IT hardware, roughly $10 must be spent on additional investments in employee training, business process re-engineering, systems administration and other producer services (Varian 2001). (These findings all correspond to co-author Snyder's own experience with IT projects over the past thirty years, including five years as Chief of Information Systems at the U.S. Internal Revenue Service from 1971 to 1975). While rigorous comparable data are not available regarding total IT-related expenditures in education, a variety of surveys suggest that public K-12 schools typically spend less than $1.00 on training and system change for every dollar they invest on hardware and software (Macavinta 1997).

NEW SOCIAL TECHNOLOGY

Adding computers to a traditional, authoritarian, hierarchical, compartmentalized bureaucracy is about as productive as adding spark-plugs to a steam engine! To fully realize the productive potential of a new physical technology, it is necessary to redesign our existing "social technologies" – i.e. our institutions; either that, or invent entirely new ones. While *physical technologies* are the products of how we organize and apply our physical materials and resources, *social technologies* are the products of how we organize and apply our human, financial, and information resources. Social technologies chiefly take the form of institutions. Insurance, libraries, taxation, hospitals, labor unions, "neighborhood watches," environmental regulations and marriage, etc., are all typical social technologies. In education, books, blackboards and computers are familiar physical technologies, while classroom-based instruction and achievement tests are characteristic social technologies.

Western civilization developed the authoritarian, hierarchical, vertically integrated bureaucracy as an effective social technology for maximizing the productive yield from a succession of new physical technologies: steam power, electric motors and internal combustion engines. In the industrial era, to assure the continuous timely flow of the multiple materials and components required for the mass production of sophisticated goods, manufacturers sought to be *internally self-sufficient*. Henry Ford not only made his own tires, he grew his own rubber. The Saturday Evening Post made its own paper. In keeping with this "vertical integration" paradigm, most companies in the 20th Century kept their own books, hired and paid their own employees, and owned and operated their own plants and equipment.

While the business press reports the steady spread of purposefully applied IT in a growing number of trades and industries, no single, compelling archetype of post–industrial social technology has emerged yet to complement IT's diverse productivity-enhancing potentialities, and to replace the hierarchical industrial bureaucracy. However, throughout the mature industrial economies today, large, vertically-integrated corporations are disaggregating themselves; disassembling themselves by contracting out big pieces of their operations to other firms. In the industrial era, outsourcing was characteristically employed as a cost-cutting expediency; but in the information-intensive economy, outsourcing has become a strategic necessity.

Outsourcing Information Overload

As IT has made the diverse details of each component of modern enterprise increasingly measurable and linkable to other components of an organization's operations and its environment, the context of every decision has become more complex, more problematic, and much more difficult to optimize. ***More* data has made decision makers *less* certain.** By the late 1980's, "information overload" began to be a serious problem for a growing number of firms, starting in the electronics and automotive industries (Flaig 1992). Corporate efforts to improve organizational capacity to deal with modern complexity – including "knowledge management" – have largely proven costly failures. As a consequence, an increasingly common corporate strategy for dealing with information overload has become simply to outsource it.

Instead of self-sufficiency, the essence of enterprise in the information economy will be *collaboration*. By contracting-out in-house functions at which they are **not** particularly adept to outside specialists who **are**, businesses are able to attain much higher growth rates and profit margins merely by leveraging their non-core expenditures through better-performing partners. Outsourcing non-core competencies also permits firms to devote more of their resources and management attention to those in-house activities whose superior performance gives the organization its competitive market-place advantage; the activities at which the organization is most competent.

Obviously, the kinds of collegial collaboration between buyer and seller that will be required among the participants in such distributed enterprises are unlikely to arise out of traditional, arms-length, minimum spec/lowest bid procurement contracts. Successful partnerships are negotiated, not dictated. The Nobel Prizes for Economics in both 1996 (Montague 1996) and 2001 (Hilsenrath 2001) were awarded for work demonstrating that *symmetrically-informed* marketplace transactions are more productive for the transactors **and** the economy as a whole than are transactions in which either the buyer or the seller is incompletely informed regarding essential details of the exchange. Clearly, procurement practices will have to be dramatically changed to assure symetrically-informed contractual relationships become the norm in the distributed enterprises of the information economy.

From Vertical Integration to Virtual Integration

In successful distributed enterprises, the diverse outputs of multiple suppliers are orchestrated – largely via the Internet – into harmonious streams of finished goods and/or services. In the process, "vertically-integrated" industrial era enterprises are transforming themselves into "virtually-integrated" information era enterprises. The working dynamics of these new social technologies are detailed by the authors of 2 current books: Donald Tapscott, in **Digital Capital**, and Grady Means and David Schneider in **MetaCapitalism**. These and other writers argue that productive and profitable businesses today have abandoned self-sufficiency to better compete in the emerging marketplace, where large enterprises will no longer be monolithic corporate entities, but will be embodied in networks of suppliers, service providers, practitioners, producers and customers. These extra-preneurial networks – called "business webs" by Tapscott, and "value-adding communities" by Means and Schneider – are emerging prototypes of *the new social technology that will supplant industrial bureaucracy*.

Grady Means simply asserts, "In the New Economy, the network will be the business!" (Walker 2000). The evangelists of corporate unbundling are equally certain that this new institutional paradigm applies just as well to public enterprise as it does to private. And, while outsourcing by public institutions is a politically and legally contentious subject, Means is particularly enthusiastic with respect to the performance-enhancing potential of unbundling public agencies. What's more, in 2001, Mr. Means, a senior partner at PricewaterhouseCoopers, took charge of PwC's government consulting services in Washington, DC, where the current Administration strongly supports outsourcing – i.e. privatizing – public sector operations in general, *and privatizing public education in particular*. While future political developments cannot be reliably forecast, strong political propensities generally presage future political actions.

Of course, schools at all levels of education have been outsourcing their non-instructional functions for decades – e.g., food services, transportation, security, etc. – as well as some special education. And, post-secondary schools commonly engage in a wide range of inter-institutional collaborations, ranging from shared facilities to joint degree programs. But recent disaggregation in the private sector has been much more fundamental. At Volkswagen's new Brazilian assembly plant, 80% of the workforce are employees of Maxion, Cummins, Rockwell, etc.; subcontractors whose suspensions, engines and brakes are going into vehicles that Volkswagen designs and markets . IBM, in an even more radical departure from tradition, began to outsource the assembly of its PCs to its *retail dealers* in 1997! Because most PCs sold in the

U.S. today are equipped and configured to meet each individual buyer's specific requirements, IBM found it was more cost-effective to order the PC components from its suppliers to be shipped directly to its dealers for final assembly, rather than attempting to mass produce custom-tailored machines on their factory assembly lines. The dealer assembly strategy proved so successful for IBM that every major U.S. PC brand except Dell now offer dealer-customized machines.

The VW and IBM examples reflect an emerging pattern in the general restructuring of American enterprise: *the separation of producer services from actual production*. Increasingly, major brand-holders are electing to retain research and development, design and engineering, process management, contracting and marketing as their core competitive competencies, while outsourcing the actual production of their product or service to others. In many service sector markets, the split between producer services and production is reflected by the growth of franchising, in which individual owners operate local outlets of nationally-branded services that are designed, developed and marketed by the corporate brand owner (e.g., Starbucks, Mailboxes, Kinkos, McDonalds, etc.). In many respects, charter schools, home-schooling and some distant learning arrangements reflect an institutional reconfiguration of K-12 education similar to the franchising movement; individual teachers or independent schools undertake to teach curriculum content and meet achievement standards set by the "branding" institution: i.e., the state or local school system.

Outsourcing Schools

Some proponents of charter schools are working toward a future when all public schools will be outsourced. In their vision for the future of education, the civil authorities will stipulate a core curriculum and physical operating standards, provide capitation-based funding, and test to certify student achievement, while a mixture of contractors – public and private, national chains and local institutions – will actually operate the individual schools. Whether or not such a future is in store for U.S. public education depends upon the unpredictable dynamics of politics. But our understanding of where value is added in manufacturing versus where value is added in education suggests that the restructuring that is working for mass-produced goods and services may not be appropriate for America's public schools.

In the late 1980s, James Quinn and his colleagues at the Tuck School of Business at Dartmouth College published their findings that between 75% and 85% of the value added by the average U.S. manufacturer is attributable to *producer services*: e.g., research & development, product design, quality control, logistics, recruitment, training, marketing and management policies and practices, etc. "The price that a manufactured product can command in the marketplace reflects the product's content of materials and labor **much less** than it reflects the quality, characteristics and availability of the product," all of which are determined by producer services, or management (Quinn, et al 1987). Management's contribution to successful performance in manufacturing is so highly leveraged that outsourcing the actual assembly of a product involves a relatively modest risk of unacceptable outcomes.

By comparison, findings published by the Educational Testing Service (ETS) in 2000, correlating student performance with three measurements of teacher performance, showed that *the largest effects upon student achievement are associated with the specific classroom practices used by individual teachers*. On average, superior teachers add 70% of a grade level to their students' math test scores, and 40% of a grade level in science tests! The same report found that the second biggest impacts on student achievement were associated with professional teacher development activities that support specific classroom practices. (These net differences remained **after** taking socio-economic factors into account, using data from the year 2000 National Assessment of Educational Progress in 8^{th} grade math and science.) (Classroom 2000). Neither IBM nor VW would have outsourced the assembly of their branded products if **that** much variability in their final products' quality were in the hands of their rank-and-file employees.

The performance of the individual classroom teacher is so substantial a determiner of student achievement in K-12 schools that the proponents of charter schools are entirely justified in their belief that any school anywhere, given adequate resources, sound management and qualified teachers, should be able to deliver satisfactory levels of student achievement. But the ETS research found a correlation between superior student achievement and ***specific classroom practices***, such as "hands-on learning activities" and "an emphasis on higher-order thinking skills." Published accounts of charter schools offer little evidence that such schools typically promote proven best classroom practice (Symonds, et al 2000). There is also little evidence to suggest that out-sourced schools have produced improved student achievement (Ascher, et al 1996). To the contrary, after reviewing the 1999-2000 achievement test scores from 376 charter schools in 10 states, the Brown Center for Education Policy at the Brookings Institution concluded that charter school students were anywhere from one-half to one full year behind their public school peers (Toppo 2002).

Old Schools for the New Century?

While a few U.S. charter schools offer wonderfully innovative curriculum and instructional methods, the great majority are largely indistinguishable in their day-to-day functioning – and classroom content – from the mainstream public schools they are supplanting. The singular common distinction of charter schools is their relative freedom from central office micro-management and, in some cases, union rules. Indeed, it is clear from the educational press that significant numbers of teachers, administrators, parents and members of the general public today believe that, if traditional classroom-based schools could somehow be freed from the pernicious influences of heavy-handed bureaucracy, teachers unions and partisan politics, the same classroom-based schools that we invented to deliver public education at the end of the 19th Century would be perfectly satisfactory social technologies for delivering public education in the 21st Century.

Techno-economic historians (David 1990) and contemporary productivity analysts (Johnson 2002) agree that substantial improvements in economic performance largely arise from the creation of new social technologies that make the fullest use of the productivity-enhancing features of new physical technologies. There is every reason to believe that education, like the other major institutional components of our national enterprise, will ultimately transform itself – or be transformed – in order to fully exploit the instructional potency of our maturing information technologies. Even if some combination of circumstances – or stakeholders – temporarily forestalls the redefinition and redesign of schooling, the combined workforce/workload/workplace realities of the next ten to fifteen years will coerce productivity-enhancing innovations out of America's labor-intensive educational institutions. However, the outsourcing strategy that is working for the mass production of durable goods and franchised consumer services does not appear to be particularly promising for education, at least so long as outsourced education retains the form of our primary industrial-era educational social technology: classroom based instruction.

The persistent reliance of formal education upon verbal classroom instruction is noteworthy for two reasons:

1.There are, in fact, other proven effective ways to teach/learn, including peer instruction, contextual learning (apprentice-internship), correspondence courses, team learning, games and simulations, etc.; and

2.Large numbers of students – up to perhaps 70% – are predominantly visual or tactile-kinesthetic learners who do not acquire knowledge effectively in the passive auditory mode of learning that is characteristic of most classroom instruction (Chion-Kenney 1992). The disconnect between differing instructional and learning styles can be absolute. Researchers at the University of Utah Hospital have used non-invasive magneto-encephalography scans to measure the electro-magnetic waves around students' heads as they learn new subject matter. When students who learn visually – as determined beforehand by diagnostic tests – are given visual instruction, the encephalogram reflects high levels of brain activity. When the same students were given solely verbal/auditory instruction, the brain scan was flat (Vuko 1999).

While most pedagogical research does not produce such startling clinical evidence of a link between teaching techniques and learning styles, over the past 20 years, a growing body of literature from studies of human development and brain functioning has given us ample reason to believe that, by establishing only classroom-based, lecture mode teaching systems, industrial era educators seriously dis-advantaged millions of people who do not learn effectively in a passive auditory mode. They also ignored both Socrates and Aristotle, who pointedly observed 2,500 years ago that different people learn in different ways. Unfortunately, although the concept of multiple learning styles is now widely acknowledged among educators, and even though there are a variety of effective and accepted non-lecture instructional methods, the adoption rates for these alternative learning processes, while increasing recently, remains quite low.

Outsourcing Classes

One class of alternative learning arrangements with a long history of proven success cannot be easily accommodated within the confines of classroom-based education: contextual learning, including intern and apprenticeship programs, community service learning and cooperative education. While such "experiential" learning is commonly associated with career preparation – e.g., doctors, plumbers, diamond cutters, etc. – the U.S. Department of Defense (DoD) has been using "functional context education" since the 1950s to teach general literacy and math skills to recruits through practical, job-related assignments. A 1987 Ford Foundation study of this program found that individuals experiencing contextualized education had consistently higher test scores and overall improved achievement than individuals completing traditional classroom education. "[Contextual learning] was judged to be more effective than traditional teaching for all levels of aptitude, and unusually effective for lower-aptitude individuals" (Sticht 1987, cited in Parnell 2001).

With 1.5 million uniformed personnel in hundreds of locations around the world, the U.S. Defense Department is uniquely able to provide contextual learning assignments for thousands of their own entry-level recruits. But, with 200,000 new enlistees every year, even the DoD can't find enough in-house slots for all those individuals requiring reading and math improvement. Thus, the Army must continue to put recruits through traditional classroom instruction to impart skills which most of them failed to learn in a classroom setting in the first place. Among educational institutions, research universities are able to offer in-house practicum for their technical students, but for most post-secondary institutions, and for all middle and high schools, contextual learning generally requires the involvement of organizations *outside* of the educational institution itself. **Schools must outsource contextual learning!**

The current "disassembly" of America's large, vertically-integrated corporate bureaucracies is being driven by the rationale of "retaining what we do well and outsourcing what we're not particularly good at." If confronted with this choice, the leadership of most educational institutions would presumably elect to retain classroom instruction as one of their core competencies; something that most educators feel they do well. Contextual learning, on the other hand, is something that traditional educational institutions cannot, by and large, provide in-house. In order to afford its students access to the proven benefits of internships, community service projects, cooperative learning, etc., educational institutions will have to enter into ongoing collaborative relationships with private and public sector employers, and with community organizations to design and conduct real-world experiential learning processes that will synergize with classroom curriculum.

The demographic realities of the coming decade will provide employers a growing incentive to collaborate with schools in a variety of ways, since the increasing shortage of qualified workers is expected to make all competent labor more valuable – and more costly. (Authors' note: This will be an even more pressing reality in Europe and Japan, where the labor force will age even more rapidly than in the U.S., and where the labor force will grow much more slowly.) In an analysis of data from the 1997 National Employer Survey, the Institute for Research on Higher Education at the University of Pennsylvania found that employers who maintain long-term school-to-work initiatives – e.g., mentoring, internships, joint curriculum development, etc. – have a 25% turnover rate among their 18- to 25-year-old employees, while the turnover rate for 18- to 25-year-olds was 50% at firms which did not collaborate with their local high schools (Bronner 1998). On the face of it, this would appear to be an opportune moment for educators and employers to explore how they might collaborate more purposefully to improve both the productivity of American education and the achievement of its students, while significantly evolving the social technology we call "school" through greater integration of education with employment.

NEW PHYSICAL TECHNOLOGY

Even as reformers, educators, parents and politicians wrestle over the future of America's schools and classrooms, we will all be inundated by a cornucopia of new physical technologies. From now on, as an ongoing consequence of the advancing information revolution, the veil of ignorance will be lifted much more rapidly from every frontier of knowledge. As our capacity to gather, store and manipulate information inexorably increases, breakthroughs in bio-technology, genetic engineering, proteomics and nano-technology are already filling the media and appearing in marketplace applications. These and other emerging technologies will turbulate our political and legal environments over the next ten to twenty years, but they will still be immature innovations, unlikely to change day-to-day life for most of us anytime soon. On the other hand, a dramatic surge of mature information technologies is 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 performance shows them on track to achieve mass-market volumes within five to seven years. Of the adolescent information technologies that will become marketplace mature during the next five to ten years, four have transformational implications for education in America and around the world:

[1] High speed Internet; [2] Open source software; [3] Groupware; and [4] Conversational computing.

Broadband: The High Speed Internet

The business press has lumped the failed promise of broadband (high speed) Internet together with the dot.bomb collapse as part of the same over-hyped tech-speculation bubble. In fact, broadband Internet in the U.S. has actually enjoyed a marketplace adoption rate that has been **faster** than that of color television, cell phones or CD players. Essentially all big businesses and most large public institutions have high-speed access to the Net, including roughly two-thirds of all U.S. schools, up from one-half in 1998 (Thomas 2001). While slightly less than 10% of U.S. households had high speed Internet access at the end of 2000, that's a 1,000% increase over what it was in 1998. Unfortunately, the communications industry had projected a 2000% increase in residential broadband! What's more, the IT industry had expected millions of U.S. employers and families to be spending $billions p.a. by now on high speed Net accessories like video-conferencing equipment, disk burners, and big, flat, high-resolution color monitors, etc., to permit them to digitally download, play, copy and share their favorite television shows, movies and music videos.

The consumer electronics industry assumed there would be a boom in home "eye-fi" equipment sales as soon as large numbers of households had broadband Web access, largely because the high speed Internet is so much faster at transmitting graphic images than the old, dial-up Internet. Using standard narrow-band access with dial-up modem, it takes about 40 hours to down-load a feature length motion picture, while the same film can be down-loaded in 7 1/2 minutes over broadband. High speed video-streaming also makes video-conferencing so easy, cheap and effective that "virtual travel" has replaced at least 5% of actual business travel since 9/11. Pioneers in virtual schooling – both teachers and students – 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, and visuals can be made three-dimensional. With broadband access, the Internet is transformed into a teaching/learning medium of unparalleled potential. It also becomes a remarkably productive administrative tool.

"Frictionless Commerce"

The Giga Information Group, which monitors e-commerce, estimates that the average overhead cost of a typical paper purchase order in the U.S. ranges between $50.00 and $75.00, including all archival, retrieval, error correction and internal audit expenses (Technology 2000). In the public sector – including education – overhead costs for paper purchase orders have been variously estimated at $100.00 to $150.00 (Jones 2000). By comparison, the average overhead costs for an on-line purchase order range between $1.00 and $5.00. Similarly, the consulting firm Booz Allen

Hamilton estimates that the average overhead costs for a cash or paper (check) transaction is $1.07, while the same transaction over the Internet has an average overhead cost of $0.01 (Lerner 2000). Because of these compelling savings, the great majority of private and public institutions are expected to transfer their commercial transactions to the Internet over the next five years. In 2000, investment banker Goldman Sachs projected that the transactional efficiencies of the Internet, **by themselves**, would 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)

"Info-mated" Equipment"

In addition to its high transmission speed, broadband Internet links have the advantage of being always on – "24/7," as they say – not dialed up as 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, toll booths, mini-marts, and ATM's etc. What's more, with broadband access, Web-enabled vending machines notify their service managers whenever they are out of order or vandalized. The H-P Laserjet 4100 printer orders a new toner cartridge *for itself* from the supply contractor in time for it to arrive just before the old cartridge runs out. Remote diagnostics over the Net will ultimately eliminate one half of all office equipment and home appliance service calls.

"Distributed Computing"

In addition to frictionless commerce and info-mated equipment, the general adoption of high speed, always-on, Internet access will also foster the growth of distributed – or "Grid" – computing. Currently, the most prominent example of distributed computing is the UC/Berkeley's SETI@home project, which uses the Internet to mobilize the idle computing capacity of 3.5 million home and business computers in 224 countries on all 7 continents to [S]earch for [E]xtra-[T]errestrial [I]intelligence in the universe. The University provides volunteers with 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 midst of the cosmic background noise. In 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 modeling protein folding, searching for anti-AIDS drugs and exploring long-term climate change (Johnson 2002).

Last Fall, the National Science Foundation (NSF) began to install the hardware for the TeraGrid, a permanent trans-continental network of four regional supercomputers that is widely expected to catalyze a general conversion to distributed computing, in much the same way that NSF's original ALOHAnet – later ARPAnet –

gave rise to the Internet (Waldrop 2000). The primary goal of TeraGrid and its international counterpart, DataGrid, is to provide the switching infrastructure for a national information grid which, like the national electric power grid, will transfer data and computational services – specific software, memory, e-mailing lists, etc. – wherever they are required for as long as they are required, to be paid for only as long as they are required. Once it is installed, grid computing will permit users to tap into the supercomputing power latent in the idle capacity of all participating computers with just a few key strokes, and for just a few cents.

In a world where all problems are becoming quantitatively more complex simply because we are gathering more data about more phenomena, the need for supercomputing is quickly becoming routine. In ten years or less, grid computing is expected to have transformed information services over the Internet into a public utility, like water, electricity and gas, supplying software, data storage and computational services to homes and businesses on demand. By 2010, most large institutions, public and private, will have outsourced the bulk of their in-house information systems to "The Grid." The NSF is supporting the development of the Grid Physics Network (www.griphyn.org) a Grid-based system to support advanced research in physics, which is expected to serve as a general model for supporting all scientific research (Hafner 2001). All but the largest institutions of higher education will "subscribe" to a grid service for all of its computing needs.

The best laid plans, etc, etc…

Frictionless transactions, info-mated equipment and distributed computing will combine to make IT a pervasive feature of daily life in America, once most of us get high speed Internet hook-ups. Unfortunately, current conventional wisdom among high-tech industry leaders argues that the only way to immediately create a mass-market demand for high-speed Internet access would be, in effect, to expand the Web into a mass entertainment medium, over which movies, music, and videos would be down-loaded, generating an enormous cash flow for the owners of popular "intellectual property." In fact, movie moguls and music producers are eagerly planning to sell their products directly to consumers over the Internet, bypassing theaters, retailers and distributors. But they are **un**willing to make their valuable intellectual property available in digital form over the Internet **until** there is some way of preventing consumers from making and sharing digitized – i.e., perfect – copies of the music and movies that they have purchased.

Industry experts believe that the bulk of the U.S. consumer public is unlikely to sign up for broadband Internet service at $40 to $60 per month unless it offers them a substantial amount of high quality visual content – i.e. entertainment. The producers and publishers of popular content have refused to make their valuable visual content available over the Internet until the IT industry installs disabling features in all their products to prevent the duplication of copyrighted material. The IT equipment makers respond that disabling devices would add to the cost of their products, degrade picture quality and ultimately be circumvented by hackers anyway. They insist that it should be the content owners' responsibility to protect their own intellectual property through encryption, an expensive and problematic proposition in itself. This inter-industry argument has dragged on for several years, and in July 2001, the Brookings Institution released a study concluding that IT industry forecasts for peak U.S. adoption of broadband would be delayed by five years, from 2007 to 2011; and that the national economy would likely forego $1/2 trillion in annual GDP growth as a result (Waters 2001).

GETTING HI-TECH BACK IN HIGH GEAR

In crossing the threshold from low-speed, dial-up Internet to high-speed, always-on Internet, the U.S. high-tech boom lost enough momentum to cause the entire economy to slow down. On September 6, 2001, after a series of speeches warning that the high price of high-speed Web access was threatening to stifle the entire Information Revolution, Bill Gates' publicly asked the federal government to intervene in the marketplace to reduce the retail price of broadband Internet access nationwide by 40%. The significance of Mr. Gates unprecedented request was lost in the aftermath of September 11th, but the widely-perceived problem has given rise to legislative proposals in the U.S. Senate to use government grants, loans and tax credits to promote high-speed Internet access in low-income urban and rural areas.

The proposed Senate initiatives are intended to both boost broadband use and to close a putative "digital divide" between Americans who have access to broadband and those who don't. In the U.S. House of Representatives, a bi-partisan coalition is promoting a more "market-driven" approach to re-starting the broadband boom. The Tauzin-Dingell Bill would require the IT industry to install duplication disablers in all the equipment it sells. This legislation would also free the four remaining Baby Bells from statutory competitiveness requirements. While this would permit the Bells to substantially reduce their broadband access rates, the competing cable companies (who currently control 2/3 of the residential broadband market), oppose this legislation because they believe it would give the Bells an unfair marketplace advantage, (which it would).

The duration and outcome of the current political debate over how best to jump-start our lagging high tech boom are entirely uncertain, especially since the White House has refused to take sides on the issue. (Dreazen 2002) Fortunately, a new type of broadband access technology – rapidly becoming available throughout the country – may just make any pending Congressional legislation moot. The technology, called Wireless Local Area Networks (WLANs) or "Fixed Wireless," uses the free, public access portion of the broadcast spectrum (802.11) to provide wireless high speed Internet access to anyone within 300 feet of a transponder connected to the broadband Internet. Originally designed to provide wireless Musaklike services throughout large buildings, the technology – popularly known as "Wi-Fi" – is now being used by airports, hotels, libraries, restaurants and universities to provide high speed wireless access to the Web for anyone within their facility (Mossberg 2002).

"Wi-Fi" to the Rescue!

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); and 2 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 20 mile radius! (Markoff 2002) This means that a single school can now extend high speed Internet access to its entire neighborhood or community at a trivial cost. Most laptops and Web-enabled palm computers will come equipped with a Wi-Fi "card" from now on. Existing machines can be retro-fitted for $70-$90, which is expected to drop to under $20.00 within a year.

At school, WLANs will permit students with laptop or palm computers to download projects from their 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 also enable educational institutions to deliver on-the-job learning to the work site, better support students in home schooling, and reach underserved learners throughout the community. In a broader, socio-economic context, schools can use extended WLANs to give the students and communities they serve a bridge over the "digital divide" between the information "haves" and "have-nots," as well as permitting them all to leapfrog the broadband impasse caused by the squabble between the IT and entertainment industries. This technology can truly make a school into an educational center with a civic circumference.

In a recent survey of teenagers, the Pew Internet and American Life Project was told that most teachers do not assign homework requiring use of the Internet simply because not all students have Web access outside of school. (McCarthy 2002) Low cost universal wireless broadband access will immediately eliminate that very substantial 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 palm type 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 experimentation, discovery and invention in educational software …, and in education.

Linux

The massive, rapid roll-out of low-cost, wireless Internet access is widely expected to force down the broadband subscription fees charged by the Bells and cable companies, ultimately abating the need for government intervention. (Authors' note: This does not necessarily mean that the government will not intervene anyway.) In much the same way, the rapidly expanding use of *open-source software* could reduce Microsoft into a mere shadow of its former monopolistic self before the Microsoft antitrust case draws to a close. 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 and Dell, etc. – have announced new products usable 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).

For people unfamiliar with the technical details of computing, the recent emergence of a strident debate between the proponents of "open" vs. "closed," or proprietary software comes across either as high-tech esoterica or a philosophical conflict 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.

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 task, quick to share everything that we learned about how to get our dinosaur to do what we wanted; almost all software was open. But, 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 micro-computers – Apples, PCs – in 1981, the numbers of computers needing programs to carry out common tasks – e.g. word processing, scheduling, spread sheets, games, graphics, etc. – quickly reached the millions, a mass-market for which both the products and the tools used to make them 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.

Meanwhile, 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 1991, MIT computing pioneer Richard Stallman and Finnish programmer Linus Torvalds created a powerful Unix-like **non**-proprietary software development language called 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* – the growing number 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 users.

By comparison, the vendors of proprietary software – like Microsoft and Unix – believe that a program's particular source codes are what give it distinctive market value, and thus, should remain the property of the company that developed it. (You don't "buy" software from Microsoft and other proprietary vendors; you 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 initial cost, at US $885 per school lab, **plus** periodic license renewals – typically $100.00 per computer – was simply too expensive to install throughout Mexico's 140,000 public schools. The Linux setup cost is $50 per lab, with no future fees required (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 – e.g. a security fault, dissonant feedback loop, etc. – they notify the entire open source programming community, from which a team of volunteers is selected to 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.

Software Wars

Eager to get out from under the yoke of proprietary operating systems and exorbitant software licensing fees, users around the world began rapidly converting to open source programming as soon as it became available for their applications. In some cases, entire industries have begun to convert to open software, from New York merchant banks and brokerage houses to Hollywood film studios. In January of this year, the Korean government ordered nearly one-fourth of agency 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 (Innovation 2002). A dozen other governments, including Britain and France, announced their commitment to open software standards in 2002.

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 palm-type 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. business software market by 2010, up from 15% 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, and Microsoft has reportedly offered the Mexican government substantial discounts from its standard charges.

The low cost of open source operating systems (OS) also permits equipment vendors to drop the basic price of computers. Walmart is currently selling a Microtel

PC with a Linux OS for under $200.00. But, 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 fight over phonics. Because $billions in cash-flow will be at stake, the SoftWars will get mean. (Microsoft officials have already called the open software movement “a cancer” and “un-American.” (Krim 2002) And because the long-term future clearly belongs to open systems, 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.

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 1970s, to enable hundreds of individual programmers to contribute simultaneously to a single piece of software involving millions of lines of code. Thirty 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 – until the past twenty-four months. 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, Gnutella and Aimster, not only permit the members of any self-selecting group free 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. 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, where schedules, assignments and resources can be posted, and the teacher and students can interact in real time. Of course, students can just as easily set up their own P2P groups to collaborate on class projects, and in which 3rd parties – e.g. mentors, experts, etc. – can participate. 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.

In fact, Peer-to-Peer networking is so cheap and easy to use that, whether or not educators incorporate P2P into 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, the AOL 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 and their ilk share any kind of digital file, all of which are searchable by title, author, or keyword. Over the next 24 months, growing numbers of Net-connected students of every age will use freely-downloadable P2P software – e.g. www.groove.net – 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 throughout the nation and around the world.

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, for example, have been using the instant messaging features of their Web-enabled cell-phones to send each other correct answers to questions during tests (Lewis 2000).

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. Teachers, professors and trainers in every field should already be working closely with their students to explore the potential 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 otherwise 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 productivity of 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 maintaining 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 avenue for valuable graduate feedback, plus revenue derived from refresher courses, on-line continuing education, and career planning updates, etc. P2P groupware on the Internet can provide educators a "window" on 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 personal and institutional innovation and entrepreneurship.

Conversational Computing

While groupware, WLANs and the high-speed Internet will all enhance our ability to communicate with each other, conversational computing will enhance our ability to communicate with *things*. By 2010, most routine commercial transactions (travel, purchases, reservations, etc.), will take place over the phone or the Web between a human and a virtual personality (Kurzweil 2000). In fact, within 10 years, a great deal of our equipment – automobiles, appliances, etc. – will be capable of speech recognition and voice replication, as well as being able to learn a variety of simple spoken instructions, i.e. to be verbally programmable. Speech is the simplest, fastest form of human communication, and our mastery of conversational computing will, by itself, hugely increase general economic productivity by eliminating large numbers of order takers, source data inputers and other information intermediaries. Within a decade, most home appliances and office equipment – including computers – will be self-explaining, at which point virtually **anybody** will be able to use computers and the Web, *including the illiterate*. Without any formal training! Meanwhile, programmers are currently developing a wide array of virtual personalities – or "personologies" – with which to endow our computers, and which will eventually include the voices of media stars and popular cartoon characters (Guernsey 2001).

Ray Kurzweil, a pioneer of optical scanning and conversational computing, believes that, in less than 20 years, virtual personalities will be so good that "people will begin to develop full, rewarding relationships with their computers." (Maney 1998). Long before that, however, the children of all industrialized nations will have become quite accustomed to chatting with machines. Many new toys already feature inter-active personalities that are able to learn hundreds of words, and to distinguish Dick from Jane, Mom from Dad, and Puff from Spot. Toys are also being programmed to distinguish red from green, 3 from 8 and right from wrong: e.g. "Don't play with fire," "No hitting!" "Say no to drugs," etc.

As the decade progresses and computing power continues getting cheaper and more compact, personologies will become increasingly realistic, with 3000-word vocabularies and multiple conversational gambits. Although they will not be sophisticated enough to fully satisfy adult expectations until after 2015, personologies will become enormously popular with young people over the next 5 years. Some will become media stars. Meanwhile, growing numbers of younger children – preschool through Grades 1-3 – will become emotionally attached to/dependent upon their personology-endowed toys. There are already therapists who specialize in personology-induced child pathologies, and no doubt, parents will soon be suing toy companies for alienating their children.

In spite of these and other tabloid controversies, all of us will find ourselves dealing with virtual personas more often in the near-term future, especially as millions of us subscribe to Web-enabled cell-phones so that we can dictate and listen to e-mail while they're on the move. And, in 10 years or so, most new homes will incorporate "smart house" technology, featuring an amiable household personology who will record messages, keep track of family members' schedules (and their important personal belongings), plus adjust individual room temperature, lighting and audio-visual environment on verbal request.

While today's adults will spend the coming decade getting accustomed to dealing with increasingly sophisticated virtual personalities, most U.S. children from now on will grow up having interactive relationships with their talking toys as a part of their earliest childhood memories. By the end of this decade, most children will enter formal schooling drilled and skilled in the dynamics of learning as much by their "smart" toys as by their parents. As they grow up, their talking dolls and electronic slates will be supplanted by talking cyber-tutors that will be filled with basic reference sources – e.g. dictionary, atlas, class assignment schedulers, etc. – all accessible just by asking.

The personologies that will be mass-marketed during the coming decade will be primitive by the standards of sci-fi movies, and certainly will not approach what academics formally define as "artificial intelligence." However, as micro-processors and memory media get smaller and cheaper, it will be possible to use a mix of sophisticated programming and chip design to create *reasonably competent virtual advisors within narrow subject-matter domains*: e.g. paramedic, power plant maintenance, automobile service, landscape gardening, etc. These chatty cyber-associates, programmed to be helpful, resourceful and cheerful, will be the direct descendents of today's PDA (personal digital assistant.) By providing employees with verbal access to expert systems, equipment simulations, decision algorithms, etc., the new cyber-aides will add substantially to average worker productivity at all levels of employment in every field. They will also make employees more interchangeable among job assignments, *while reducing the need for traditional employee training*.

Like broadband Internet access, open source programming and peer-to-peer groupware, conversational computing will be an increasingly powerful presence on the pedagogical scene for the forecastable future. Personal cyber-tutors will be a significant factor in teacher-student relationships by the decade's end. But nearer-term, as the actual manipulation of computers and the Internet increasingly requires only natural spoken language, education at all levels will have to focus more on imparting to all students the generic skills for using the information resources and services that are about to become common features of daily life and work.

ON THE THRESHOLD OF . . .?

Whether or not the 2001 Recession returns in 2003, 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 a sufficient number of appropriately-skilled human resources**. Since the mid-1990's, when the high tech boom first became evident in the national 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 3 to 1 margin.

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 1990's 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 this year's renewal of the Higher Education Act be modeled on last year's 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 the political process just at this moment is far more problematical than the money that can be freed up by:

A. Moving all commercial transactions to the Internet;
B. Shifting from expensive proprietary software to free, open source software;
C. 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.;
D. Outsourcing in-house computing operations to outside providers or to a "grid" service.

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 in work-place/life-long learners in the face of a significant shortfall in the teacher supply will make it necessary for us to substantially improve the productivity of our teachers and our educational processes. 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 our basic social technologies: classrooms and schools. And necessity, as Plato observed, is the mother of invention.

The future has begun!

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.

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

Ascher, Carol, Fruchter, Norm & Berne, Robert, "Hard Lessons: Public Schools and Privatization," *A Twentieth Century Fund Report*, 1996, pp. 1-2.

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

Bronner, Ethan, "Benefits of School Business Alliances," The New York Times, July 8, 1998.

Brynjolfsson, Erik and Yang, Shinkyu, "Intangible Assets and Growth Accounting: Evidence from Computer Investments," working draft research report from MIT Center for eBusiness, (http://ebusiness.mit.edu/erik), May 17, 2001, p2.

Chion-Kenney, Linda, "The Ways We Learn," *The Washington Post*, April 6, 1992, p. B5.

"Classroom techniques make the difference," *USA Today*, October 17, 2000, p. 6D.

Cohen, Linda R. and Noll, Roger G., "Privatizing Public Research," *Scientific American*, September 1994, p. 73.

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.

Dreazen, Yochi J., "Tech Firms Bemoan Bush Talk," *The Wall Street Journal*, June 21, 2002, p. A4.

El Nasser, Haya, "Census predicts ethnic face of the nation in 100 years," *USA Today*, January 13, 2000, p. A-3.

Flaig, L. Scott, "The 'Virtual Enterprise:' Your new model for success," *Electronic Business*, March 20, 1992, pp. 153-154.

Francese, Peter, "The American Work Force," *American Demographics*, February 2002, pp. 40-41.

Goodnough, Abby, "More Applicants Answer the Call of Teaching Jobs," *New York Times*, February 11, 2002, p.A-1.

Grossman, Ron and Leroux, Charles, "Research Grants Actually Add to Tuition Costs," *The Chicago Tribune*, January 28, 1996, pp. 1-19.

Guernsey, Lisa, "The Desktop That Does Elvis," *The New York Times*, August 9, 2001, p. 1, 6.

Hafner, Katie, "Machine-Made Links Change the Way Minds Can Work Together,"

The New York Times, November 5, 2001.

Hayden, Thomas, "Science of Safety," *U.S. News and World Report*, December 31, 2001, p. 60.

Hilsenrath, Jon E., "Three Americans Win Nobel for Economics," *The Wall Street Journal*, October 12, 2001, p. 1.

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

"Innovation to Soar with Abundant Free Software," *Trend Letter*, January 7, 2002, pp. 1-2.

"Investment in employees profitable, researchers find," *The Register Guard*, Eugene, Oregon, June 6, 1995, p. B5.

Johnson, Bradford C., "Retail: The Wal-Mart Effect," *The McKinsey Quarterly*, (www.mckinseyquarterly.com/home), McKinsey Global Institute, 2002.

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

Kurzweil, Ray, "Merging Human and Machine," *Computer Graphics World*, August, 2000, pp. 23-24.

Kyantrowitz, Barbara and Wingert, Pat, "Teachers Wanted," *Newsweek*, October 2, 2001, p. 37.

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.

Macavinta, Courtney, “Study tracks school tech use,” *CNET News.com*, (http://news.cnet.com), November 12, 1997, p. 1.

Maney, Kevin, “Some are struck dumb by speech-recognition software,” *USA Today*, November 11, 1998, p. 4B.

Marklein, Mary Beth, “Study urges colleges to boost standing of part-time faculty,” *USA Today*, January 14, 1999, p. 10-D.

Markoff, John, “Two Tinkers Say They’ve Found A Cheap Way To Broadband,” *New York Times*, June 10, 2002.

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

Montague, Bill, “Winners link info, economy,” *USA Today*, October 9, 1996, p. 2B.
Mossberg, Walter S., “A Guide to the Lingo You’ll Want to Learn for Wireless Technology,” *The Wall Street Journal*, March 28, 2002, p. B2.

Perlstein, Linda, “Schools Cautioned on Hasty Hiring,” *The Washington Post*, September 16, 1998, p. A-12.

Parnell, Dale, *Contextual teaching Works!* CCI Publishing, Waco, Texas, 2001, pp. 51-76.

Quinn, James Brian, Baruch, Jordan J., & Paquette, Penny Cushman, “Technology in Services,” *Scientific American,* December, 1987, p. 56.

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

“Schoolforge Coalition Formed to Advance Open Resources in Education,” *linuxtoday.com*, (http://linuxtoday.com/news) January 8, 2002.

Symonds, William C., “For Profit Schools,” *Business Week*, February 7, 2000, pp. 64-76.

Sticht, Thomas, Armstrong, William, Hickey, Daniel, Caylor, John, *Cast-off Youth: Policy and Training Methods from the Military Experience*, Praeger Publishers, New York, 1987, p. 98.

Talacko, Paul, “A connection without wires,” *The Financial Times*, January 22, 2002.

Taylor, Robert, “Bridging the Digital Divide,” *The Financial Times*, February 23, 2001.

“Technology and Increased Productivity,” *USA Today*, January 31, 2000, p. 3B.

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

Toppo, Greg, “Study: Charter School Students Score Lower,” *The Washington Post*, September 3, 2002, p. A-7.

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

Varian, Hal R., “New Economy,” *The New York Times*, September 10, 2001.

Vuko, Evelyn Porreca, “Right-Brain, Left-Brain Learning Dance,” *The Washington Post*, March 22, 1999, p. C4.

Walker, Leslie, “The Bigger Boom to Come,” *The Washington Post*, July 13, 2000, p. E1.

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

Weiss, Rick, “In Recognizing Surprise, Researchers Go From A to B to Discovery,” *The Washington Post*, January 26, 1998, p. A-3.

Waters, Richard, “Delays in high-speed broadband may cost U.S. economy $500bn.,” *Financial Times*, July 16, 2001.

Zernike, Kate, “Tests Are Not Just for Kids,” *Education Life*, August 4, 2002, p. 26.

Zhao, Yilu, “As Endowments Slip at Colleges, Big Tuition Increases Fill the Void,” *The New York Times,* February 22, 2002, p. A-1.

“Academic Research and Development: Financial and Personnel Resources, Support for Graduate Education, and Outputs,” *Science and Engineering Indicators – 2002*, National Science Foundation, 2002, pp. 6-2-15.

“Employment Projections 2000 to 2010,” *Occupational Statistics and Employment Projections*, U.S. Bureau of Labor Statistics, Dec. 2001, Tables 1-3.

“Resident Population Projections by Sex and Age,” *Statistical Abstract of the United States*, U.S. Census Bureau, 2002, Table 14.

“School Enrollment: 1965 to 2009,” *Digest of Education Statistics*, U.S. National Center for Education Statistics, 2002, Table 239.