PART III

THE STRATEGIC CONTEXT OF EDUCATION IN AMERICA

2000 TO 2020

by

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Consulting Futurists

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AUTHORS' NOTE

In PART 1 of this three-part series, we examined several 10-to-15-year demographic and economic projections for the USA that pose significant future implications for all educational institutions. These projections included:

- *the Baby Boom Echo will swell student populations at all grade levels (K-16) through 2020;*
- *one-third of the nation's teachers and nearly half of all school administrators will reach retirement age by 2015;*
- *the entry-level labor pool from which most new faculty and staff will be recruited during the next 10 years will have been born during the low-birth "inter-Boom" years – 1965 to 1985 – and are projected to produce insufficient numbers of recruits to meet the combined realities posed by growing school enrollments and mass faculty retirements;*
- *the current technology-driven restructuring of the U.S. workplace will require a growing majority of all employees to be not simply literate and numerate, but also to be able to communicate effectively, think systematically, and learn continuously – all of which will require the development of new curricula and new measures of student achievement.*

At the close of PART 1, we posited that these underlying long-term trends will increasingly place the USA's educational institutions in untenable circumstances. In particular, we argued that even if sufficient fiscal resources become available, by 2010-2015, there are unlikely to be sufficient numbers of qualified faculty to staff the nation's classrooms at current student-teacher ratios.

We opened PART 2 of The Strategic Context of Education in America by presenting an historic model of the maturation and socio-economic dissemination of new technology. In *the past, new technologies have typically taken half a century to achieve marketplace maturity. Once they have reached maturity, new technologies have, in turn, routinely given rise to decades of enhanced economic performance as productivity-enhancing innovations are adopted throughout all value-adding activities and operations. The 200-300% increases in the USA's annual productivity-improvement rates since the mid-1990s are now commonly cited as evidence that information technology (IT) has become a mature workplace tool. PART 2 concluded with an assessment of five recently-introduced IT applications with significant potential to increase the productivity of educators, and thereby address the challenges posed by impending workload/workforce/workplace realities. Those applications were: [1] Broadband Internet; [2] Distributed Computing; [3] Wireless Internet access; [4] Open Source Software; and [5] Groupware.*

While preparing PART 2, we found that both technology historians and economists agree that a new physical technology, ***by itself****, has little impact on economic productivity. Specifically, in order to affect the performance of an entire national economy, a new physical technology must: 1. be supported by a purpose-built infrastructure, and; 2. be conjoined with the complementary new social technologies. The breakthrough electro-mechanical technologies invented during the 1870s and '80s, for example – generators, motors, electric light bulbs and sewing machines, etc. – did not produce significant improvements in economic performance until an infrastructure – the electric power distribution grid – was constructed, beginning in 1905, to supply factories, homes and offices with electricity. The Internet, we posited in PART 2, is the infrastructure – or "info-structure" – for the computer.*

Annual analyses by the U.S. Federal Reserve System and others found that computers generated no detectable improvement in U.S. economic performance until the Worldwide Web added graphics, color and data transmission to the Internet in 1993-94. At that point, our basic info-structure was complete, and our annual productivity improvement rates immediately doubled! Annual productivity improvement in the US has continued to rise since the mid-1990s, reaching a 50-year high in 2002.

Meanwhile, during the 1990s, micro-economists and research accountants began to publish findings which strongly suggested that, while significant systemic increases in U.S. productivity were directly attributable to the Internet, most specific improvements in economic efficiency within individual enterprises were substantially dependent upon the adoption of new ***social technologies*** *– new ways of organizing people, capital and information – that permitted firms to exploit IT's specific capacities to enhance their marketplace performance. In PART 3, we review fundamental innovations in social technology that have been linked to the USA's increased productivity improvement rates, and assess the applicability of those and other IT-based social inventions to the delivery of education in America.*

RESTRUCTURING INSTITUTIONS, RE-ENGINEERING WORK

(The Real Information Revolution)

The Austro-American economist, Joseph Schumpeter, famously characterized the ongoing transformation of economic enterprise by successive generations of productivity-enhancing technology as "waves of creative destruction." In fact, information technology has sent two separate and distinct waves of creative destruction rolling through the U.S. economy and around the world. One wave – restructuring – is changing the way enterprises are organized, while the second wave – re-engineering – is changing the content of work itself. Both restructuring and re-engineering possess considerable potential for transforming educational institutions and redesigning the content and process of education.

RE-STRUCTURING INDUSTRIAL ERA INSTITUTIONS

Authoritarian, hierarchical, vertically integrated bureaucracies emerged as social technologies to exploit the power of two 19th Century physical technologies – the steam engine and electricity – for the mass-production of goods. To assure the continuous timely flow of the manifold materials and components required to mass-produce sophisticated goods, manufacturers sought to be *internally self-sufficient*. Henry Ford not only made his own tires, he grew his own rubber trees. The **Saturday Evening Post** made its own paper. In pursuit of "vertical integration," most large 20th Century enterprises – private and public – kept their own books, owned and operated their own plants and equipment, and hired and paid their own employees.

During the 1990s, however, large, vertically-integrated corporations in the USA and around the world began to disassemble themselves by contracting out **both** their administrative services **and** their non-core operating functions to other firms. In the industrial era, outsourcing was employed primarily as a cost-cutting expediency; but in today's data-dense decision-making environment, outsourcing has become a strategic imperative. Firms are abandoning vertical integration for *distributed collaboration*, not only to cut costs, but also to reduce "information overload" (Flaig, 1992).

Outsourcing Information Overload

As maturing information technology has permitted the details of every component of enterprise to be recorded and linked 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* information has made decision makers *less***

certain. By the late 1980s, *information overload* began to be a serious problem for planners and decision-makers in the largest and most complex organizations, starting in the U.S. electronics and automotive industries (Port 1991, Flaig 1992). Corporate efforts during the 1990s to improve institutional capacity to deal with modern complexity – including "enterprise resource planning" (ERP) and "knowledge management" – largely proved to be dismal and often costly failures (Fisher 2001, Wysocki, 1998, Bulkeley, 1996). As a consequence, an increasingly common corporate strategy for reducing information overload has become simply to outsource it.

Instead of integrated self-sufficiency, the essence of enterprise in the information-intensive marketplace will be *distributed collaboration*. Grady Means and David Schneider, at the accounting firm of PricewaterhouseCoopers, have found that, by contracting-out internal 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 by leveraging their expenditures on non-core activities through better-performing outside partners (Walker 2000). Outsourcing non-core operations also permits firms to reduce capital expenditures and to devote more of their resources and management attention to those in-house activities whose superior performance gives the enterprise its competitive market-place niche or advantage.

The collegial collaboration between buyers and sellers that is required among the participants in such distributed enterprises is unlikely to arise out of traditional, arms-length, fixed-spec/minimum 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 research demonstrating that *symmetrically-informed* marketplace transactions are more productive for **both** 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, common procurement practices will have to be dramatically reconceptualized to assure that symmetrically-informed contractual relationships become the norm in the distributed enterprises of the information economy. Like most of us, in the coming decade the nation's purchasing officers and sales representatives are about to undergo a cultural change.

From Vertical Integration to Virtual Integration

In successful distributed enterprises, diverse inputs from multiple outsourced functions are orchestrated – largely via the Internet – into harmonious streams of finished goods or services. In pursuit of this new ideal, vertically-integrated industrial era enterprises are transforming themselves into disaggregated information era enterprises whose multiple specialist components are "virtually integrated' via the Internet, using "groupware," one of the instrumental information technologies discussed in PART 2 of *The Strategic Context of Education* (DeMaria 2003, Keenan, Ante, 2002).

The working dynamics of these new social technologies are detailed by the authors of two recent books: Donald Tapscott, in **Digital Capital**, and Grady Means and David Schneider in **MetaCapitalism**. They and other business writers argue that the most productive and profitable firms today are abandoning self-sufficiency to better compete in the emerging marketplace, where large enterprises will no longer be monolithic entities. Increasingly, major enterprises will be embodied in networks of suppliers, 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' formulation for future corporate enterprise is straight-forward: "In the 'New Economy,' the network will be the business!" (Walker 2000).

Outsourcing by public institutions is a politically charged and legally contentious subject, but the evangelists of corporate disaggregation are confident that the new organizational paradigm applies just as well to public enterprise as it does to private (Irwin 2001, Osborne and Gaebler 1992). Of course, schools at all levels of education have been outsourcing 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 organizational disassembly in the corporate sector today is taking place on a much larger scale. Multi-national enterprises – like Bank of America, BP and International Paper, etc. -- now routinely outsource entire administrative functions – e.g. finance and accounting, facilities, logistics and human resource management, including recruitment, training, payroll and benefits management (Skapinker 2002).

A growing number of firms are also contracting out their production operations. At Volkswagen's new Brazilian assembly plant, 80% of the workforce are employees of Maxion, Cummins, Rockwell and other subcontractors whose suspensions, engines and brakes are being installed in vehicles that Volkswagen designs, markets and services. IBM, in an even more radical departure from industrial tradition, began to outsource the assembly of its PCs to its **local resellers** 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 local resellers 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, in less than a year, every major U.S. PC brand except Dell was offering dealer-customized machines (Forest 1997).

The VW and IBM examples of corporate unbundling reflect an emerging pattern in the general restructuring of industrial era enterprise: *the separation of management from the actual production and delivery of goods and services*. Increasingly, major brand-holders are electing to retain key management functions – research and development, design and engineering, planning, quality control, marketing and customer relations – as their core competitive competencies, while outsourcing the actual production of their products or delivery of their services. In consumer service markets, the split between management and production is reflected by the rapid growth of *franchising*, in which individual owners operate local outlets of nationally-branded services that are designed, developed, equipped and marketed by the corporate brand owner (e.g., Starbucks, Mailboxes, Kinkos, McDonalds, etc.).

Restructuring Industrial Era Schools

The outsourcing of administrative services offers K-16 educational institutions a means of reducing their costs while improving the quality of workplace life. As we discussed in Part 2 of The Strategic Context of Education in America, contracting out in-house computer services to an information utility like IBM or H-P can be expected to reduce an organization's total data processing outlays by 20% to 55%. On-line procurement services Epylon and SchoolHouseLink report that they are able to cut the average overhead costs of school purchase orders from $125.00 apiece to $25.00 (Jones 2000). In the face of **both** ongoing public sector austerity **and** rising educational costs, there will be growing incentives for educational institutions to outsource their administrative services during the next 36 to 48 months.

The general rush to outsource administrative functions is validated by the fact that, by engaging in a single area of practice – e.g. facilities management, personnel services, etc. -- outside vendors are able to provide better services at lower costs. In particular, firms specializing in human resource management and financial services typically bring with them state-of-the-art computerized personnel management, payroll and cost-accounting systems whose capital costs the vendor can spread across dozens of client organizations. And, because a large number of contract administrative services firms are now competing in the commercial marketplace, the outsourcing of such services to private sector suppliers by public institutions like schools raises fewer legal questions or intractable political debates than it would have just five years ago. Privatizing more intrinsically governmental functions, like law enforcement, environmental protection – and public schooling – on the other hand, is likely to remain a much more fractious proposition.

Charter Schools: "franchising" public education

In many respects, charter schools, home-schooling and some distant learning arrangements reflect an institutional configuration of K-12 education similar to the business franchising model. "Franchisees" – in this context, home-schooling parents and charter schools – undertake to teach curriculum content and meet achievement standards set by the "branding" institution: i.e., the state or local school system. 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, 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 – private and public, national chains and local institutions – will actually operate the individual schools. Unfortunately for this scenario, our understanding of where value is added in commercial mass production versus where value is added in education strongly suggests that the kinds of organizational restructuring that are improving marketplace performance for mass-produced goods and services may not be particularly beneficial for America's public schools.

In the late 1980s, James Quinn and his colleagues at Dartmouth University published their findings that between 75% and 85% of the value added by the average U.S. manufacturer is attributable to *management* functions, including research & development, product design, quality control, planning and marketing, etc. "The price that a manufactured product can command in the marketplace reflects that product's content of materials and labor **much less** than it reflects the quality, characteristics and timely availability of the product," all of which are determined by management's inputs. "In industries such as autos or pharmaceuticals, the cost of management's inputs to a final product can be from 3 to 10 times its direct labor costs, and such services can provide virtually **all** the perceived distinction between a product and its competitors." (Quinn, et al 1987). *Management's contribution to successful performance in mass industrial production is so highly leveraged that outsourcing the actual fabrication 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*. Teachers using superior practices add an average 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 8th grade math and science. (Classroom 2000). Neither IBM nor VW would have outsourced the assembly of their branded products if a 40% to 70% variation in their final products' quality were in the hands of their rank-and-file employees!

Classroom instruction: 20th Century cottage industry

The range of variability in the average teacher's impact on student achievement reflects the fact that the actual practice of teaching has remained largely unchanged in Western civilization since the Renaissance. Teacher-mediated learning was scarcely touched by the Industrial Revolution. There was no Frederick Taylor for public education; no one analyzed 19th Century classroom performance or prescribed detailed, research-based "time and motion" efficiency standards for teachers to follow. Conversely, most 20th Century educators did not actively embrace reformer John Dewey's challenging prescription of dynamic classrooms and project-based learning. Over the past 100 years, public schools have increasingly been housed in buildings whose exterior architecture has conveyed the impression of contemporary professional enterprise. But, within those purposeful contemporary structures, classroom instruction has basically remained a pre-industrial cottage craft.

Because they have (so far) avoided a formulaic regimentation of their practice, individual classroom teachers have remained the nexus of the educational process and the principal single determiner of student achievement. This would appear to validate the belief by proponents of charter schools 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 did not simply find that student achievement varied randomly among different teachers; they found correlations 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 to date offer little evidence that such schools typically promote proven best classroom practice (Symonds, et al 2000). There is also little evidence to suggest that outsourced schools have produced improved student achievement (Winerip, 2003, 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 typically between 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 superior 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 all charter schools is their relative freedom from central office micro-management and, in some cases, union rules. What's more, 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 the Europeans first developed to deliver public education in the 17th Century would be perfectly satisfactory social technologies for delivering public education in the 21st Century.

Whether or not charter schools ultimately deliver superior student achievement using traditional, teacher-mediated, classroom-based learning, it seems unlikely that the traditional classroom setting under **any** circumstances will provide a hospitable context for exploiting the instructional potential of information technology. In a recent survey of sixty poor rural elementary schools in South Carolina, James Guthrie, a professor of public policy and education at Vanderbilt University, counted more than 10,000 computers in 2,000 classrooms. While he found large numbers of students practicing low-level keyboarding skills in computer "labs," he saw students actually use a computer in a classroom *only twice*! Subsequent surveys in Colorado and Tennessee produced similar results (Guthrie 2003). The typical teacher-mediated classroom does not foster computer-mediated learning.

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

- first, there are a number of other proven effective ways to teach/learn, including peer instruction, contextual learning (apprentice/internship), correspondence courses, games and simulations, etc.; and

- second, large numbers of students – up to perhaps 75% – 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 techniques 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 produced by students' brains as they learn new subject matter. When students who learn visually – as determined beforehand by diagnostic tests – were given visual instruction, the encephalogram reflected 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 striking clinical evidence of a link between teaching techniques and learning styles, over the past twenty years, a growing body of literature from studies of human development and brain functioning has given us ample reason to believe that, by relying primarily upon lecture-based, classroom instruction, industrial era educators have seriously dis-advantaged millions of people who do not learn effectively in a passive auditory mode (Powell, 2003). To the extent that males make up the majority of tactile kinesthetic (active) learners, this mismatch almost certainly contributes to the growing disengagement between U.S. males and education from kindergarten to grad schools (Conlin, 2003). Unfortunately, although the concept of multiple learning styles is now widely acknowledged among educators, and even though there are a variety of effective, accepted non-lecture instructional methods, the adoption rates for these alternative learning processes, while increasing recently, remains quite low.

Even older schools for the new century?

One type of alternative learning arrangement with a long history of proven success cannot be easily accommodated within the confines of classroom-based instruction: contextual learning, including intern and apprenticeship programs, community service learning and cooperative work-study education. As a social technology, apprenticeship has its roots in pre-classical history, and almost certainly predates the classroom and written language. In the U.S. today, such contextual – or "experiential" learning is commonly associated with specific career preparation (doctors, plumbers, diamond cutters, etc.). At the same time, over six hundred U.S. post-secondary institutions (out of 4,000 total schools), incorporate workplace assignments as formal components of their general academic degree requirements (Applestein 2000). And 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, work-based learning 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. DoD is uniquely able to provide in-house contextual learning assignments for thousands of their own recruits. Among educational institutions, research universities are able to offer in-house practicum for many of their professional and technical students, (consulting projects, internships and laboratory work), 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. Most U.S. high schools have eliminated their laboratories as a cost and liability cutting measure, although these hands-on environments are now being replaced by computer simulations (Morriss, 2002, Bulkeley, 1996).

Outsourcing contextual learning

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

The demographic realities of the next fifteen years will provide employers increasing incentives to collaborate with schools in a variety of ways, since the growing shortage of qualified workers is expected to make competent labor more valuable – and more costly. 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). In an earlier survey of employers for the U.S. Labor Department, the Census Bureau discovered a further reason for employers to collaborate with educators.

On average, a 10% increase in worker educational attainment produced an 8.6% increase in productivity, while a 10% increase in hours worked produced a 6.6% increase in output, and a 10% increase in capital investments resulted in only a 3.4% increase in output (Applebome 1995).

On the face of it, this would appear to be an opportune moment for educators and employers to explore how they can collaborate more purposefully to improve **both** the productivity of American education **and** the achievement of its students, while significantly enhancing the performance of the participating enterprises at a time of rising foreign competition for a rapidly growing range of industries. Not only would such collaborations serve the multiple interests of students, educators and employers alike, but the recently-introduced IT innovations described in PART 2 of *The Strategic Context of Education in America* will facilitate the on-line integration of classroom instruction with real-world experience in reading, writing and systematic thinking – including math – to solve problems. Ultimately, many outsourced contextual learning assignments can be simulated by interactive learning software developed by students, employers and teachers. Since most schools will be unable to mobilize sufficient numbers of actual work assignments for **all** of their students, the creation of computer simulations of workplace activities will be essential in order to provide most students with the benefits of contextual learning.

As we spelled out in PART 2, growing numbers of vendors are offering groupware – both free and for fee – with a rich array of features – instant messaging, file sharing, video-conferencing, etc. – specifically designed to foster on-line collaboration among geographically and organizationally dispersed individuals. (A comparative review of the seven most popular peer-to-peer instant messaging – IM – systems appeared in the June 26, 2003, issue of *Network Computing* magazine (DeMaria 2003). Schools that choose to outsource their administrative functions – finance, procurement, human resources, facilities management, information services, etc. – will be able to use readily available generic groupware to "virtually re-integrate" their disaggregated functions with their core enterprise. But there is, as yet, no off-the-shelf groupware specifically designed to facilitate educator-employer collaboration on such crucial tasks as curriculum and job design, student assessment and counseling, mentoring, etc. These tools can best be invented by the instructors, employers and students who pioneer such innovations, using low-cost open source software, (another timely IT innovation described in PART 2).

RE-ENGINEERING INDUSTRIAL ERA WORK

Not only is there no off-the-shelf groupware to foster educator-employer collaboration, but no software of any kind has yet been shown to consistently improve the instructional productivity of the relationship between classroom teachers and their students. In the corporate world, surveys have variously shown that only between 8% and 15% of major business IT projects actually generate significant measurable improvements in performance. Studies of those successful projects help to explain the near-absence of productive teacher-computer collaborations in U.S. classrooms.

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 productivity 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" (Investing 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 five-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, $9.00 to $10.00 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 IT-related expenditures in education, a variety of surveys suggest that *public K-12 schools typically spend less than $1.00 on training for every $1.00 they invest on hardware and software,* ***and nothing at all on system change or job redesign*** (Thomas 2000, Macavinta 1997).

Adding computers to a traditional, authoritarian, hierarchical bureaucracy is about as productive as adding spark plugs to a steam engine! And yet, this is basically what schools have done. Small wonder that researchers have found no positive correlation between the use of computers in the classroom and student test scores (Shifting 2003). Interestingly, most businesses find themselves in much the same circumstances, since the 10% to 15% of firms that have actually developed productivity-enhancing uses for IT are understandably reluctant to share the secrets of their success with their competitors. And, having experienced poor returns from their previous expenditures in IT, the remaining 85% to 90% of large U.S. businesses are now reluctant to make further major investments in information systems. This, in turn, has contributed to the current three-year drought in IT sales.

IT vendors are understandably reluctant to tell prospective buyers that they will need to make enormous investments in job redesign, process re-engineering and training **before** their new computer system will increase their productivity and profitability. In this respect, the IT industry itself has contributed to the current slump in equipment sales, as Xerox CEO Anne Mulcahy spelled out in an address to the Information Work Productivity Council (IWPC) in March, 2003.

> "It's no secret that technology alone is not enough. Yet many customers continue to buy IT – and many [of us] continue to sell IT – that way. Productivity is **not** embedded in software code! Business improvement does **not** come in a box! Technology requires changes in the way humans work, yet companies continue to inject technology without making any of the necessary changes. Why? Because it's easier to write a check than it is to rethink the way you work." (Abrahams, 2003)
>
> Anne Mulcahy, CEO
> Xerox Corporation
> Address to the Information
> Technology Association
> March, 2003

One month after Mulcahy's speech, the IWPC endowed MIT's Sloan School of Management with $4.5 million to establish a Center for Information Work Productivity. The Council was formed in 2002 by the world's principal IT firms – Cisco, H-P, Intel, Xerox, Microsoft, Accenture, BT and SAP, etc. The Director of the new research Center, Professor Erik Brynjolfsson (see above) has been given two assignments:

1. Develop and publish rigorous measures of productivity in information work, so that the economic benefits of computerization can be accurately assessed using commonly agreed-upon criteria; and

2. Compile and publish detailed case studies of successful IT projects for a wide variety of standard applications in a large number of different industries.

Professor Brynjolfsson also intends to assemble a library of best practice in applied IT (Abrahams 2003). All of the Center's findings and publications will be made freely available over the Internet at Center for Business @ MIT. While the IWPC's funding of the new MIT research can scarcely be regarded as an act of disinterested altruism, the Center's work is likely to play a major role in accelerating corporate America's productive assimilation of IT. From now on, the business world will have Prof. Brynjolfsson and his colleagues as guides to help them "rethink the way they work." The teachers and administrators of America's schools, however, will largely be on their own.

REFORMING INDUSTRIAL ERA SCHOOLS

In the early 1990s, the US. Labor Secretary's Commission on Achieving Necessary Skills (SCANS) issued a series of reports intended to put some "meat" on the bare rhetorical bones of "Goals 2000," a vaulting six-point commitment to public school improvement made by the nation's Governors and President George H.W. Bush in 1989. In its 1991 report, *What Work Requires of Schools*, the Commission spelled out thirty-seven basic intellectual skills and applied competencies that the nation's employers agreed would be required of all jobs in the post-industrial workplace (What, 1991). A number of local school boards adopted the SCANS list verbatim as their districts' learning objectives. A year later, SCANS published a follow-up report, *Learning A Living*, in which they detailed the comprehensive transformation of America's public school classrooms from passive to participative learning environments. Only inter-active instruction, the report asserted, would enable **all** students to learn the expanded array of core content and processes in the new post-industrial curriculum (Learning, 1992).

The second SCANS report also recommended that public schools drop their traditional letter grading system for a standards-based system benchmarked against a student's demonstrated degree of mastery with respect to specific topics or tasks. In the past decade, only one state (Oregon), has adopted the SCANS participative classroom and "standards-based grading" model. Those reforms, which are still evolving, have already proven effective in reducing the achievement gap between the State's affluent and poor students (Graves, 1995, Graves, 1998, Lawton, 1999). Since 2000, a growing number of school districts have begun to adopt "standards-based grading" (Chicago, Louisville and Green Bay, Wisconsin, etc.) largely as a means of forcing teachers to initiate more participative classroom practices (Tomsho, 2002). While these reforms appear to be working, they are exceptions to the *status quo*.

Having failed to respond constructively to the heroic aspirations of Goals 2000, U.S. public schools have now been committed to the much more rudimentary benchmark testing requirements of No Child Left Behind. While Goals 2000/SCANS called upon educators to re-invent classrooms to teach new, higher-order skills for the "Information Age," No Child Left Behind calls upon educators to demonstrate that they are actually achieving the basic instructional objectives of the Industrial Age. However, these goals, too, are proving to be heroic. As different as they are, SCANS and NCLB share a common fundamental characteristic with proprietary software. Like software, both initiatives stipulate a set of specified steps intended to optimize putatively similar operations – public school systems. a And both SCANS and NCLB were designed, or "programmed," by outsiders – i.e. employers (for SCANS) and politicians (for NCLB) – *who do not actually participate in the process they are seeking to optimize!*

Moreover, *neither* software manufacturers *nor* public policy makers can afford the time and resources to produce products that can accommodate the actual diversity of the marketplace or society. Both the makers of mass market goods and the framers of legislation characteristically standardize, equivocate and equilibrate their outputs to address ***average*** consumer/constituent needs and problems, forced by their circumstances to ignore the complex details that differentiate the individual circumstances of their users and constituents. As a result, proprietary software regularly forces users to do things that they do not need or want to do; judicial sentencing guidelines and welfare means tests routinely produce unintended, unjust outcomes. Similarly, it is now readily apparent that standardized exams, such as the NCLB benchmark tests, do not accommodate the diverse abilities and limitations of disabled students or children who are non-native English speakers (Matthews, 2004, Dillon, 2004), in recognition of which, the Department of Education was ultimately forced to relax the standards for those student populations.

Proponents of open source programming argue that their approach to software development produces superior results, in part because open source systems are typically designed, tested and refined by actual users based on actual tasks or problems in a real world context. The voracious capacity of open source collaborative communities to identify, address and solve problems on a continuous basis is a major reason why the "open innovation" concept is rapidly spreading beyond software development to serve as a means of mobilizing practitioners for successful innovation in **any** field of endeavor.

In many high-tech industries – from semi-conductors and telecommunications to genetic engineering and pharmaceuticals – firms are reducing their reliance on in-house (proprietary) R&D and using an "open innovation" process to mobilize "communities of competence" among their employees – and among their customers' and suppliers' employees – to address practical problems of common interest, to exploit new technology and to develop new and improved products or services. (Hamilton 2003) In a recent article in the *MIT Sloan Management Review***,** Harvard Business School Professor Howard Chesbrough reported that "this trend goes well beyond high technology – other industries such as automotives, health care, banking, insurance and packaged consumer goods – have also begun leaning toward open innovation" (Chesbrough, 2003).

OPEN INNOVATION VS. PROPRIETARY INFORMATION

Significantly, the actual implementation of open innovation has so far been largely limited to in-house systems – within individual firms or consortia of firms – whose management expects to use patents and copyrights to establish corporate ownership of the useful products and processes created by their employees. Patents and copyrights are essentially temporary monopolies granted by governments to the inventors of physical devices and systems and the creators of textual or graphic materials. Since the outset of the Industrial Revolution, it has been commonly understood by business and political leaders that ownership of intellectual property must be legally established and protected as a necessary incentive for creative people to devote their rare talents and limited resources to the difficult and problematic pursuit of breakthrough innovations. Today, however, an increasingly vocal alliance of scientists, legal scholars, consumer advocates, librarians and economists believe that the proliferation of patents, especially in the U.S.A., is actually constraining scientific research and technical innovation, and that more innovation can be stimulated by freely sharing information than by protecting it (Williams, 2003).

As data has gained commercial value in our increasingly information-intense decision-making environment, the debate over the definition and ownership of intellectual property will become more fractious than the fight between the proponents of phonics and immersion reading instruction, or the competition between proprietary and open source software. Over the past twenty years, U.S. Courts have repeatedly rejected the notion that factual data can be copyrighted, denying claims that telephone companies "owned" the subscriber information in their phone books, or that realtors had exclusive proprietary rights to the housing data published in their listings. In a 1991 ruling against the realtors, the U.S. Circuit Court asserted that, since the data was a matter of public record, the public should be able to have free access to the realtors' housing data, even if the only practical way to extract those data would be to copy the entire realtor data base.

The current debate over the accessibility of information is unlikely to be resolved in the near term future, especially since major corporate owners of data bases – publishers, bio-tech firms, makers of proprietary software, etc. – are aggressively promoting data-base protection legislation in Congress that would permit firms to copyright the data they publish, and to charge fees for accessing that data (Waldmeir 2004). The proponents of "open access knowledge" fear that the private ownership of data that have already been published will severely curtail the ability of future researchers and practitioners to build upon prior knowledge in order to make new discoveries and create new products. And, since all organized information -- including graphics, music, architectural design, fiction, etc. -- will eventually be digitized and stored as a data base, legal exerts and libertarians warn that the pending legislation would permit current copyright holders to claim ownership of the basic components of all art and design, all composition, and every figure of speech or turn of phrase.

In 2003, as an alternative to the statutory "enclosure" of the building blocks of future intellectual creativity, Lawrence Lessig, a Stanford University law professor, established "Creative Commons," a Website to help artists and composers get their works published under a General Public License (GPL), which grants free universal access to their creations while protecting them from being copyrighted by others (Not, 2003). In the sciences, the move toward open access knowledge is driven not merely by the belief that it will accelerate innovation, but by growing public unhappiness over having to pay high fees for reprints of papers based on research substantially funded – directly or indirectly – by taxpayer dollars. The most dramatic open access initiative in academia has been the October, 2003, introduction of a major new scientific journal by the Public Library of Science (PLoS), a group of prominent scientists with start-up funding from private philanthropists (Harmon, 2003). The magazine, *PLoS Biology,* is free, and will be competing with established scientific journals whose annual subscription fees average $789.00, and generate profit margins of up to 30% (Weiss, 2003).

Instead of charging subscribers to read the results of their colleagues' research, *PLoS* charges researchers a $1,500 fee to publish their papers. To cover these costs, underwriters of biological research, including the Howard Hughes Medical Institute, Britain's Wellcome Trust and the U.S. National Institutes of Health, have agreed to fund these publishing fees in their research grants. *PLoS* also uses a Web-based peer-review process (as do an estimated 30% of all scholarly furbishers) that dramatically reduces overhead and cuts postage costs by up to 80% (Milstein, 2002). The Library plans to introduce a second free journal, *PLoS Medicine,* in 2004. While PLoS backers are prepared to roll out further titles, they hope that the initial success of their business model will convince many scientific journals to adopt open access publishing, ultimately revitalizing *open scholarship* in the sciences. Bio-Med Central, a parallel British effort, already fields more than one hundred free-access biomedical journals (Pearson, 2003.)

The traditional openness of scientific research has been severely constrained by the commercialization of scholarly publishing. While the original genesis of the Internet was to facilitate the free sharing of ideas and discoveries among academicians, the Web is now used by the publishers of expensive scientific journals to sell individual article reprints at $15.00 to $50.00 apiece. Not only can reprints from open access publications be freely downloaded by non-subscribers, but the data-bases from which the authors' conclusions are derived can also be downloaded, re-configured and compared or coalesced with other data to produce new insights and hypotheses to goad and guide further research.

In his comparative studies of the relative impact of new technology on economic performance in the Middle Ages and the Industrial Age, economic historian Joel Mokyr argues persuasively that the rate of invention was the same during both periods, and that the dramatic surge in productivity and prosperity that accompanied the Industrial Revolution was primarily due to the existence of established scientific disciplines with common definitions and terms, whose practitioners' were able to communicate widely with each other, and with practitioners, artisans and entrepreneurs (Mokyr, 2002, 1990). Without connectivity and "epistemic knowledge," Mokyr writes "the inventors of the Middle Ages did not know what prior practice had shown to work or not work, and thus wasted valuable time and resources in fruitless searches for things that could not be made, like perpetual motion machines or gold from base metals" (Postrel, 2002).

The seismic event that heralded the arrival of the open access movement in post-secondary education was MIT's 2001 announcement that it would put all 2000 of its courses on public access websites within ten years. The project, called OpenCourseWare (OCW) already offers 500 basic courses in anthropology, biology, chemistry and computer sciences, etc., including thousands of pages of syllabi, lecture notes, problems and exams, plus hours of video-streamed lectures, seminars and experiments, all available free-of-charge, worldwide (Hardy, 2002). MIT expects to spend $100 million over the next decade to video-record all lectures, digitize all instructional and reference materials, and to transfer all of its curriculum content from proprietary copyrights to freely usable General Public Licenses on the Web. MIT does **not**, however, plan to offer degrees for sale on-line, as many post-secondary institutions have done.

The MIT leadership and most of its faculty are reported to believe that the bulk of the value added by an MIT education derives from the *campus experience*: the first-hand interaction among the students, faculty, and other members of the campus community in an intensive learning environment. The campus environment is also expected to serve as the "laboratory" in which new curriculum content and instructional materials will be developed and refined. Meanwhile, by making their courseware freely available on-line, MIT is inviting other teacher-student learning environments – e.g. a Chilean mining institute or Bangladeshi disaster relief planning agency – to assemble customized educational programs from OCW's curricular building blocks (Goldberg, 2001). By committing itself so completely to its OpenCourseWare program, MIT will serve as both a bellwether and a barometer for open access in higher education during the decade ahead.

Projects like PLoS Biology and MIT's OpenCourseWare initiative give powerful testimony of the transformational potential of information technology in higher education. But, there are no such nationally-visible projects demonstrating the transformational potential of mature IT in K-12 schools; the one collaborative on-line community of practitioners to provide educators with a model of effective open innovation is the open source educational software developers, at <www.schoolforge.com>.

"OPEN SESAME"

Self-organizing, collaborative on-line communities are crucial to an open innovation process. In the open source software movement, for instance, there are currently over 300,000 registered user-developers supporting more than 10,000 projects. To start a new project, a user simply posts a message with one of several on-line collaboration communities (<freshmeat.net>, <geocrawler.com>, <schoolforge.com>, etc.), either submitting a newly-created program for peer evaluation and improvement, or describing a software project for which the submitter is seeking competent user-collaborators. If other members of the open source community find a newly-posted piece of code purposeful, or a newly-proposed project worthwhile, they recruit additional volunteer expertise as needed to contribute ideas, and to code, test and refine the program until a finished piece of off-the-shelf open source software is made available to all open source users (vonKrogh, 2003).

As a new piece of open source software finds marketplace applications, some new users will join some members of the project group that first created the software to maintain and improve the program based on its actual ongoing use, under the collegial principle of "learn locally, share globally." The purely voluntary nature of open source collaboration would appear to allow poorly qualified contributors to participate in development communities, compromising the quality of the software. But research has shown that collaborative developer communities are self-policing meritocracies. To become accepted as ongoing contributors to a project, volunteers have to demonstrate substantially greater technical activity than the more casual contributors. Moreover, the fact that the volunteer collaborators are typically addressing problems whose solution will be of direct immediate benefit to themselves on the job further ensures the participants' commitment and integrity.

Open source software -- and open innovation in general – are uniquely appropriate social technologies for a time of transformational change. During this era of accelerating technologic innovation and institutional change, there will no longer be fixed "best practice;" only "better practice," until a new IT application or a new social technology comes along that makes an even better practice possible. Open innovation processes can serve as the means by which competent educators – faculty and administrators – can collaborate with each other and their stakeholders to reinvent schools for the post-industrial world *one classroom at a time*. (The authors offer a "work-in-progress" exploration of the open source model as a universally applicable social technology for mobilizing and motivating knowledge workers in general, and for accelerating the pace of scientific discovery and technologic innovation in particular, at <www.cultury.com>.)

In PART 2 of this paper, we assessed five recently-introduced applied information technologies that pose transformational implications for schools: [1] the broadband Internet; [2] groupware; [3] wireless Internet access; [4] open source software; and [5] distributed computing. A recently popular form of groupware, Weblogs (or *Blogs*) offers a remarkable new potential as an electronic "teachers aide." Blogs originally emerged as on-line "soap-boxes" for IT wonks to expound upon and debate the technical subtleties and esoterica of the cyber world. But bloggerware has now evolved into powerful off-the-shelf groupware that individual teachers can use to establish class websites, where all class lectures, notes and reference links can be posted, and where students can engage their teachers and classmates in discussion. Just as there is already an on-line collaborative community for educators creating open source software for schools, collaborative on-line open innovation communities should also be established for pioneers in distance learning, distributed computing and school-based Wi-Fi, and in teacher-student use of peer-to-peer and Weblog groupware.

Open innovation systems would also be extremely helpful in promoting the use of groupware to develop successful contextual learning arrangements, from team learning and community projects to internships and simulations. Most important of all, collaborative communities made up of teachers, employers and contextual learners in open innovation processes can develop practical classroom definitions of the basic knowledge and skill sets of the post-industrial workplace – especially the critical but poorly articulated "higher order thinking skills." Teachers and their students can use freely down-loadable WIKI "idea accumulating" groupware to collaborate on developing demonstrably superior working definitions, instructional modules, materials and IT applications.

Based on field research, technologist Eric von Hippel has written that employees are characteristically unable to clearly explain the actual requirements or the contextual details of their work to outsiders. Von Hippel calls these crucial details "sticky information," and because outside programmers do not have access to this "sticky" information, proprietary software is typically a less effective workplace tool than the open source software developed by practitioners themselves (von Hippel, 1998). Teachers with students in intern assignments, apprenticeships and co-operative learning programs can use WIKI-ware to engage the participation of their students and their students' employers and co-workers to develop curriculum that incorporates the "sticky" details of real life.

NURTURING EFFECTIVE INNOVATION

It has been over twenty years since the Carnegie Endowment published **A Nation At Risk**, sounding the initial warning that America's public schools required fundamental changes to prepare students for a dramatically different future. And, it has been more than a decade since the nation's business and political leadership spelled out a detailed vision of post-industrial education. Paradoxically, while few U.S. schools have adopted any significant system-wide reforms during the past two decades, thousands of highly productive innovations have been instituted by individual teachers in individual classrooms throughout the country. Many of these successful innovations – involving team teaching, community service learning programs and computer integrated classroom instruction, etc. – have been in place for five to ten years or more, winning awards for their school systems and attracting national recognition, ***but almost never being adopted by other teachers, schools, or school districts!***

The United States has 3.5 million K-12 teachers and one-million post-secondary professors and instructors. Teaching is far and away the nation's single largest college-educated profession. Many U.S. educational institutions afford the most aggressively competent 1% of those 4.5 million professionals sufficient freedom to create hundreds of truly productive classroom innovations every year that demonstratively improve student achievement. Archives of educational research, like the Cambridge Center for Behavioral Studies, in Cambridge, Massachusetts (Crandall, et al, 1997) and the National Center to Improve the Tools of Educators (NCITE) at the University of Oregon School of Education (Carnine, 1998), have documented hundreds of breakthrough teacher-initiated classroom innovations. But short-term exigencies and institutional inertia routinely prevent local educational leaders from adopting these successful innovations, while the practitioners who create these superior classrooms typically possess insufficient time and entrepreneurial resources to promote their innovations to the larger educational community. A national open innovation process to support teacher collaboration in developing, refining and adopting the working components of the post-industrial classroom would help overcome the standing barriers to innovation in schools, strengthen the influence of competent practitioners and foster the grassroots re-invention of our educational institutions. *Real revolutions come from the bottom up, after all.*

LEADING EDUCATION THROUGH REVOLUTIONARY TIMES

Information technology will not only transform the process of education, it will also alter the future work places and life spaces for which schools prepare their students, thereby necessitating changes in the content of education as well. And because we are still early in the transformational phase of this techno-economic revolution, the precise nature of the future for which schools must prepare people will be a moving target. The re-invention of industrial era schools and curriculum for the post-industrial age will be an on-going heuristic process requiring fifteen to twenty years.

No doubt, most leaders – not just educational leaders -- would prefer to be living through more predictable times, where the future could be expected to be much more like the present. But change – predictable or not – has always been a central characteristic of the future. Indeed, 2500 years ago, the Greek historian-philosopher Heraclitus observed that "Nothing about the future is inevitable *EXCEPT* change." Two hundred years later and half a world away, the mythic Chinese warlord San Tzu advised that, "The wise leader exploits the inevitable." The inference to be drawn from these two ancient insights is plain: "The wise leader exploits change!" This is clearly what leaders throughout education must do.

Specifically, leaders of educational institutions must aggressively promote innovative uses of IT throughout their operations, particularly by classroom teachers. Progressive educators should underwrite the establishment of on-line open innovation communities to link entrepreneurial classroom teachers and career-tech instructors with employers, students, subject matter experts and alumni to co-develop new curriculum content, classroom computer applications, new groupware features, etc. The entire process – its developmental discussions, its successes and failures, the mistakes made and the lessons learned, its products and their applications – must be freely available to all (learn locally – share globally!) In addition, paralleling MIT's new Information Work Productivity Center, an open innovation process should be established to develop meaningful measures of multi-factor productivity in education. In this last endeavor, NCLB test results could prove to be a valuable resource (Higgins, 2002).

The demographic and economic circumstances of the near-term future offer the educational leader little maneuvering room and no leverage at all. The creative exploitation of technology offers not only leverage for leadership, but a means of re-engaging disaffected faculty and students, and the basis of a hopeful vision for the future of education. In recent years, leaders of educational institutions have largely been pre-occupied with budget battles, quality improvement, damage control and community relations. While such issues are unavoidable, they are principally *management* concerns, not *leadership* concerns. The primary concern of leadership is to articulate a hopeful, believable vision of the future, and to plan for making that vision happen. In the strategic context of education in America, it is now time for leaders to be articulating hopeful visions and making transformational plans.

Educators, who may understandably be reluctant to become leaders of paradigmatic change, should keep in mind that private sector "edupreneurs" are preparing to compete with traditional educators in the marketplace, using high-quality interactive electronic mass-market educational products and services (Wyatt, 1999). In the right political environment – e.g. pro-privatization, pro-sectarian/libertarian, etc. – such marketplace competition could destroy universal public education as we know it in less than a decade. Of course, since this is a time of "creative destruction," the process might also produce a superior replacement. We are, after all, passing through a genuine technology-driven socio-economic revolution of historic significance and unpredictable outcomes. This is the sort of moment in time to which history books typically devote whole chapters. A quarter century from now, entire history chips, titled "The Trans-Industrial Revolution," will describe how the great industrial era institutions, including schools, were ... or were not ... able to re-invent themselves for the Information Age.

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