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AN ERA OF CREATIVE DESTRUCTION

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Abstract

Over the course of the 20th century, the US economy has moved from rote to creativity, from a mass production workforce to a white-collar workforce whose focus is developing new products for sale. In the process, economic change has been accelerated, so that our educational process and goals are increasingly inappropriate. As an example, even the intensive education of medical doctors is inadequate to the current pace of change. In this paper, I delineate the impact of the electronic revolution that has automated routine and made creativity more profitable and therefore more powerful. I examine the high school movement (1910-1940) and the college movement (1940-1970) as successful responses to technological challenges that increased equality. I then attempt a tentative discussion of the electronic revolution's impact on the educational process.

Education and Training in an Era of Creative Destruction

Overview:

This paper provides a perspective on how the US economy is changing and the impacts that these changes are having on education. Our economy is in a period of rapid and accelerating change. The kinds of work done, and the corporations that employ the workers, are changing at a more rapid pace than ever before. In this process, the private sector has been changing faster than the public sector. The world for which education is supposed to prepare us is changing faster than education itself and faster than educators. This is true of the most intensive education we provide -- the education of medical doctors. It is even more true of the education we provide in elementary and secondary school.

The economic process we are engaged in is best described in terms of Joseph Schumpeter's theory of *creative destruction*.[1] From this perspective the US economy is increasingly devoted to *creating* new products and new work and continuously displacing – *destroying* – existing products, jobs, and firms. This differentiates creative destruction from the bulk of economic theory and practice. which has assumed that new products are relatively unimportant. When new products are relatively unimportant, we assume that individual businesses are free to use the same technology and to produce the same products as their competitors, and thus that what businesses compete over is how to most efficiently produce these products. Under creative destruction, businesses compete to produce distinctive new products that are more valuable than existing products and displace them from the market. When a business invents a new product, it can use patents, copyrights, trade secrets, and its advantage as the first one to the marketplace to establish a temporary monopoly

[1] Schumpeter's theory is set forth in *Capitalism, Socialism, and Democracy*. This theory poses direct challenges to the mainstream theory of the invisible hand first enunciated by Adam Smith (Nakamura, 2000).

over that product. If the new product is sufficiently superior, the firm reaps huge benefits from its temporary monopoly, which repays the firm for the costs and risks of the discovery process.

A rapidly growing proportion of workers is engaged in creating new products. These new products make existing products obsolete, the way that computers have made typewriters and slide rules obsolete, and CDs have made LPs obsolete. Among these new products are many that serve to automate and expedite production, eliminating jobs directly even when the product is not obsolete. These continuous shocks to the workplace imply that workers ought to be preparing themselves for a lifetime of career disruption and for repeated – if not continuous – formal education. But our educational system is designed more for sorting students into hierarchical categories by final degree earned than preparing them for a lifetime of education. How is the educational system coping with these changes? Thus far mainly in multiplying stresses on educators.

This paper proceeds first by providing an overview of economic change in the past 25 years (Sections I and II), then steps back to discuss occupational and educational change over the course of the 20th century (Sections III and IV). It then discusses some of the dilemmas confronting education, using the example of medicine to provide perspective (Section V).

I. How work is changing in an era of creative destruction

The economy of creative destruction divides workers and work into two parts or paths: creative workers who change the world, and production workers who are subjected to continuous change. As creative work is itself carried out on a leading edge that is rapidly evolving, creative workers are also subjected to rapid change.

Creative workers. Creators are workers who first must try to imagine what has never existed before and yet is more valuable than what exists. Next, they must work with production designers, managers, and producers to discover how the new product might be efficiently mass produced. Then they must communicate, first to business decisionmakers and then to consumers, why the new product is of greater value than existing products that it would supplant, and why it is therefore worth making and purchasing.

Every such act of creation is a critique of what exists and corrodes the status quo. Creativity often brings to mind imagination and artistic craft. In the abstract, we might hope that these qualities provide pleasure and beauty and thus are self-validating and do not necessarily imply conflict. While this may sometimes be true – the genius of a Giotto or an Einstein may be acknowledged without much professional conflict – it is the exception.

Every act of genuine creativity provokes resistance – and should. What is familiar is usually safe; what is new possesses unknown dangers. The power of capitalism, according to the Schumpeterian theory of creative destruction, is precisely that it gives the profits of creativity to creators and the corporations that employ them, and thereby can make creativity powerful enough to overcome the natural human resistance to change (Nakamura, 2000). That is, a corporation such as Pfizer can earn billions of dollars in profits marketing Viagra, and these prospective profits, and similar profits earned in the past, give it the power to hire workers to produce the new good, place it visibly before a wide market, and overcome the objections of those who prefer the status quo.

As we shall see in the next section, technological developments and globalization have tipped the scale decisively in favor of rapid creation, destruction, and economic change.

Production workers. Workers who are direct producers make products that have already been conceived using mass production techniques that are repeated, with minor variation, year after year. A metaphor that Paul Romer of Stanford has used is that such workers follow established recipes, while creative workers invent new recipes. As the proportion of creators to direct producers has risen, the pace of change for production work has intensified. As a consequence, productive workers cannot count on being able to stick to a given task; they find either their corporation or corporate division failing and merging, or their job content changing dramatically even as their occupation and employer remain the same.

Formal learning. With so much creativity going on, lifelong learning is increasingly necessary for all workers. This learning is "formal" in the sense that it takes place within an institutional structure, but most often it is sporadic, in refresher courses and evening classes, and while maintaining full-time employment. On average, those with a bachelor degree or higher take a career or job-related course once a year. And those with some training beyond high school take such a course nearly as often.[2]

As Shoshana Zuboff (1989) has shown, modern manufacturing techniques have tended to diminish the importance of nonverbal experience developed on the job, that is, learning developed through the day-in and day-out repetition of processes. In one case study, Zuboff studied the modernization of a wood pulp mill, one of the steps in papermaking. Under the old process, workers were like chefs, able to tell from the aroma and consistency of the pulp how the cooking was going. After modernization, workers were sealed off in an air-conditioned control room, relying on monitors and readouts for their data. This step radically disoriented many of the workers, diminishing nonverbal sensory skills, and making formal learning and interpretation skills critical.

[2] *Digest of Higher Education 1999*, Table 362. Specifically, those employees with some formal education beyond high school but no college degree took an average of .78 career or job-related courses in 1999, those with a bachelor's degree but no graduate study took an average of 1.02, and those with some graduate study took 1.17. These results are

This formal learning is not easy, particularly for those who have been labeled as failures by the educational system or the work world. While learning is a natural human activity, it involves uprooting existing habits and exchanging them for more fruitful ones and, as such, is an attack on the self. Because of this, learning is made easier when the learner is self-confident. It is hard to learn from failure, because failure tends to reduce self-confidence.

An important part of our educational system has been using success as a reward and failure as a punishment. This causes those labeled slow learners in our population to become averse to formal education, slotted to terminate their education early. Fortunately, educational movements that made high school and then college education more widely accessible have, for much of the 20th century, ensured that the supply of well-educated workers has kept pace with – and at times exceeded – the demands of new technologies. As a consequence, the wage-premium for additional high school and college education generally fell or remained low for the first three-quarters of this century, a trend that has favored income equality. Since the electronics revolution in the 1970s that trend has reversed, and inequality has been rising.

College education as learning to learn. The value of a college education has risen sharply, if we measure its impact on the earnings of college graduates compared to those of high school graduates. One important part of the value of a college education is that it better prepares the student for a lifetime of learning and change. Indeed, the ideal of the liberal college education is one of preparing a broad base for continuing learning. A consequence is that college graduates, in fact, pursue more adult education than high school graduates. Although one might guess that they are less in need of additional formal education than high school graduates, 58% of college graduates in 1994-5 took adult education courses compared with 31 – 42% of high school graduates

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driven mainly by occupational differences: managers, professionals, and technical workers usually take a course a year, while all others take half a course or less.

who lack any college education. Preparing students for relatively slow-paced careers – the traditional job of the junior high school and high school – is preparing them for a dead end.

Can we change the nature of education? The nature of education is changing already. The question is, how best can teachers and their institutions cope?

II. The rising pace of change since 1975

The barriers to economic change are lower as a consequence of rapid technical progress in electronics. In particular, progress in electronics has dramatically automated information processing and communication.

This electronics revolution has made it much easier to produce new products. Electronics have facilitated more efficient research in all areas of science and technology. The human genome project is one example of a research project where much of the work of scientists and technicians was automated and performed by machines and computers. The ability to simulate and design in three dimensions has changed work as diverse as architecture, automobile design, movie making, and fireworks displays. Computerization speeds the design and testing of almost all new products, which move rapidly from the laboratory to the market.

In addition, the rewards to change have risen dramatically. Globalization has increased the number of customers who can be sold any given new product; it is easier for any given product, whether a mustard or a sports car, to find a niche. And once the niche is found, the chances for mass sales beyond the niche are increased, as fads and specialized products become phenomena: Harry Potter, the Internet, Starbucks, minivans.

Not only are markets worldwide, but the process of retailing has been revolutionized repeatedly, making those markets far more accessible (Nakamura, 1999b). Internet commerce is just the latest in a series of innovations that help customers find products and make it possible for a huge variety of goods and services to be on offer when demanded. Scanners and universal product codes have not only sped checkout lines and reduced the cost of putting prices on items, but they make detailed daily sales information available to chain store managers, who can then more effectively and inexpensively keep track of vast varieties of items for sale and quickly replace poor sellers with superior new products. This has facilitated the superstore, which combines low prices with awesome variety.

So if you have a better mousetrap, even if the world does not beat a path to your door, your chances of being able to sell it to a Home Depot or WalMart have risen, because their business model is based on their ability to cheaply carry an additional item. As scanners and electronic cash registers became universal, the number of items carried by the average supermarket more than doubled from 9000 in 1980 to 20,000 in 1994.[3] And this greater openness to new items provided tremendous incentives to new product developers, so the number of supermarket products that were introduced annually rose even more rapidly over that period, from 2700 to 20,000 (Nakamura, 1999b).

Before the electronics revolution, a large sales force and clerical staff were required to place a new product in the mass market. As we shall see, from 1900 to 1980, corporations hired immense numbers of high school graduates to staff offices and sales counters. During that period, long-run profitability and corporate leadership in a given field were rarely in doubt. As Alfred Chandler (1980, 1994), Harvard Business School's management historian, has documented, the top firms in the early 1900s remained the top firms in the 1960s and 1970s. As he discusses in the magisterial works, *The Visible Hand* and *Scale and Scope*, US corporations made three

[3] In 1960 there were 6000 items a store, so in the previous 20 years, the number of items per store had risen 50 %.

investments: in mass production facilities, in a sales force, and in a corporate office structure to coordinate production and sales.

The consequence was that a potential rival with a new invention could only very rarely challenge the corporate leader. A new invention might make the corporate leader's production facility potentially obsolete, but it could rarely take over an important market because the sales force and the corporate office took a long time to duplicate. So the leading corporation could grind an innovative rival into submission while adopting the new technology at a leisurely, and profitable, pace. So outside inventors had to sell their ideas to the large corporation that could use them most efficiently, and rarely were paid full value. To summarize: only large corporations had the wherewithal to quickly reach consumers, and as a result, the great corporations were in control of the pace of introduction of new products. IBM, AT&T, General Motors, Ford, DuPont, Procter and Gamble, General Mills, US Steel, Standard Oil, General Electric, Gillette, United Fruit, and others like them were able to dominate research and development and then dole out new products at a pace that would not disrupt production plans and distribution networks. As a result, corporate chiefs led generally serene lives and were rarely ousted before planned retirement.

All that has now changed. Technology no longer is controlled by the corporation, and instead only those corporations that are able to repeatedly invent and use the next new thing are consistently profitable. Creators and creativity dominate the pace of work.

The great hurdle is coming up with a great product that is really substantially better than previous products. Being just as good isn't enough. But if you have a great product, the marketplace can distribute it to millions of customers in a hurry. Before the electronics revolution, setting up a distribution network for a great new product took decades. As a consequence of this change, new products that are worth hundreds of millions or billions of dollars in profits to their producers have become almost commonplace. And that means corporations are forced to spend – overall – hundreds of billions of dollars to try to invent and then market great new products. And this expenditure is far more democratic – small startups have nearly as good a chance of success as behemoths, perhaps a better chance. This is the economic spur to creativity that has made creative destruction the central mode of business of the US economy.

Another important sign of change is the US stock market. Over the past decade, the equity value of US corporations has swelled from $10 trillion to $20 trillion. Most of this increase is due to increases in the value of intangible assets, such as patents, copyrights, brand names and trademarks (Hall, 1999, Nakamura, 1999a). Moreover, the bulk of the value that has been created is in corporations new to the stock market, rather than existing corporations (Jovanovic and Rousseau). Finally, the riskiness of the stock of individual corporations has increased compared with the stock market as a whole, an indication of the increased competitive risk corporations experience as creative destruction accelerates.

What we spend money on has also changed dramatically over the past decades. The proportion of our budgets spent on what used to be necessities – food and clothing – dropped from 33 to 24% (Nakamura, 1997). And over one-third of all food expenditures are spent in restaurants, and almost all clothing is bought for style rather than function. Indeed, clothing donations have created a surfeit of used clothing in every size and shape. Data on recreational spending show that the proportion of household budgets spent on recreation in the lowest income quintile is substantially higher than it was 40 years ago. Indeed, the proportion rivals that formerly spent by the highest income quintile. Recreation expense became substantially less of a luxury in the period from 1972-73 to 1991 (Costa, 1997). These dramatic shifts testify to the dynamism of the US economy (Costa, 2000). New products are driving changes in consumer spending patterns as never before.

What other evidence do we have that the economy has changed so much? The most important evidence is that the number of workers engaged in creative occupations has risen rapidly, as we shall see in the next section. As we shall see, the proportion of such workers at the end of the 20th century was very high. These workers are among our best and brightest, well educated and experienced. They are highly paid, and their pay is justified only if they produce new products that are more valuable to consumers than existing products. That assures continuous rapid and probably accelerating creative destruction.

III. Occupational change in the 20th century

At the beginning of the 20th century, almost all workers were engaged in actually doing the physical work needed to directly produce economic output – farmers, carpenters, welders, barbers, cooks. These are the *directly productive* occupations: they include agricultural workers, industrial workers (skilled and unskilled), and direct service workers, such as barbers, waiters, and domestic servants. By the end of the century, less than half of all workers were so engaged, and the majority of workers were involved in white-collar work. These in turn are divided into two groups: *sales and clerical* workers, who, abstractly speaking, are engaged primarily in communicating information about products and data about transactions; and *managerial, professional, and technical* workers. We can usefully divide professionals into two groups: the creative professionals – those who invent, design, or create new products; and service professionals, such as doctors and teachers, who make client-based decisions.

These three groups – directly productive workers, sales and clerical workers, and managerial, professional, and technical workers – roughly correspond to three levels of educational requirements. Grossly speaking, *direct production* does not require a high school education; *clerical and service* work requires a high school diploma; and *managerial, professional, and technical* work requires a bachelor's degree. We will be using these categories to help give us a sense of how the educational requirements of work have changed over the century.

Chart 1 shows data from the U.S. Bureau of Labor Statistics' Current Population Survey that gives, for 1998, the proportion of workers over 25 in each educational group that works in a given occupation.[4] Note that over 80% of all workers with less than a high school education wind up working in direct production. And over half of all workers with only a high school diploma also wind up in direct production.

By contrast, the vast majority of college graduates and advanced degree holders are managers and professionals. Although students go to college for many reasons, including intellectual, social, cultural, and recreational ones, from an occupational perspective students go to a four-year college in order to become managers and professionals. Managerial and professional work generally requires both specific, advanced expertise and a broad knowledge of the world and the ideas by which we understand it.

Chart 2 retabulates the data in Chart 1 to show the proportion of workers over 25 in each occupational category that has a given level of education. Roughly 70% of both direct production workers and clerical and sales workers have at least a high school diploma but no more than an associate's degree. What differentiates clerical and sales work from direct production work is that, generally speaking, the minimum educational requirement is a high school diploma. Of course,

[4] Data is tabulated from the Digest of Educational Statistics, 1999, Table 384.

there are openings for checkout clerks who lack a high school diploma, but such opportunities – aside from being poorly paid – are surprisingly small in number.

In sharp contrast, 60% of managerial, professional, and technical workers have a bachelor's or more – only 40% have a high school diploma to an associate's degree (Bill Gates is in this 40%). Again, in many cases – doctors, lawyers, nurses, architects, engineers, scientists – college and often advanced degrees are occupational requirements.

Beginning in 1975, more workers were involved in the white collar activities of decisionmaking, coordination, and supervision – than in actually producing the goods and services that are ultimately purchased. And as the electronics revolution tended to automate routine aspects of white-collar work, it has increasingly centered, as I have said, on discovering new, superior products.

To give a feel for recent employment dynamics, from 1990 to 1999, the number of workers in the US increased by 15 million, to 133 million.[5] Over two-thirds of the increase in new jobs was in managerial, professional, and technical occupations, whose numbers rose from just over 34 million to just under 45 million. This group is where employment opportunity has expanded the most, and it generally requires a bachelor's degree. Direct production expanded by 3 million jobs, from 51 million to 54 million. And clerical and service work expanded by less than 2 million, from 33 million to 35 million.[6]

But instead of focusing on the most recent period, let's look at the broad sweep of history, because doing so helps us understand the relationship between educational movements and the economy. The following data is garnered from the U.S. Census of Population for the period from

[5] Data are from the U.S. Bureau of Labor Statistics' Current Population Survey, the survey that measures unemployment every month.

[6] Because managers, professionals, and technicians tend to retire later than other workers, these figures on new employment exaggerate the difference in job availability as there tends to be more attrition in the other occupations.

1900 to 1980, and for 1990 and 1999 uses data from the U.S. Bureau of Labor Statistics Current Population Survey.

The proportion of direct producers has declined steadily. The proportion of workers who are direct producers of goods and services has declined throughout the century, from a high of 82% in 1900 to 41% in 1999 (Chart 3).[7] The largest decline was in agricultural occupations, which declined relatively steadily from 38% to 3% (Chart 4). The proportion of workers in industrial occupations – manufacture and transportation of goods, for the most part – rose from 36% in 1900 to 40% in 1920. But since then it too has fallen relatively steadily, to 25%. Initially, mass production, by reducing the price of goods, greatly expanded demand. But as markets matured and as productivity continued to rise rapidly, these occupations fell in importance. Direct production of services has generally risen over the course of the century, from 9% in 1900 to 14% in 1999.

Until the electronics revolution, clerical and sales work grew rapidly. Clerical and sales work, on the other hand, rose very substantially in the first half of the century and continued rising until the electronics revolution began to rapidly automate these jobs (Chart 5). From 1900 to 1980, these white-collar occupations rose from 7 ½% of the workforce to 28%. In the first half of the century in particular, the development of mass production techniques – in the absence of inexpensive electronic devices – rapidly multiplied the demand for workers to keep track of the multiplying array of transactions. The whole point – that is, profit – of being able to produce millions of gallons of kerosene, or millions of cars, or millions of shoes, was lost if the revenues of the millions of sales did not wend its way back to the producer as efficiently as the goods were produced. During this period, as Chandler tells us, these workers were the primary line of defense

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[7] Sales and clerical workers include sales workers and administrative support, including clerical workers. Production occupations are here defined to include farming, forestry and fishing; precision production, craft, and repair; operators, fabricators, and laborers; private household and other service workers. Managers, professionals and technical workers

of the great corporation; once they became technologically outmoded by electronics, that defense was greatly impaired. Since 1980, with computers and electronics rapidly automating data processing and communication, the proportion of clerical and sales workers leveled off and then began declining, with some 26% of the workforce employed in these occupations in 1999.

The proportion of managers, professionals, and technicians has accelerated over the course of the 20th century. These workers, primarily engaged in creating new products and making decisions about products, now comprise 33% of the work force. Because they are paid twice as much per person, managers, professionals, and technicians garner half of all US wages and salaries, while direct producers earn roughly 30% and clerical and sales workers about 20% of the total.

This group includes 20 million managers, primarily employed in private businesses. These are the decisionmakers of the corporation, and they are increasingly engaged in deciding how to create new products and which new products to produce and market. There are about 4 million technical workers, including roughly a million computer programmers. And there are about 20 million professionals, of which about 13 million are service professionals, mainly doctors, nurses, and college, secondary, and primary school teachers.

Although the number of clerical and sales workers increased faster than managers, professionals, and technicians in the earlier part of the century, the decisionmaking group has steadily accelerated. They were 10% of the workforce in 1900, and 17% in 1950. During the first two decades of the century, clerical and sales workers rose from being one-fourth less numerous than the decisionmakers to 10% more numerous, and this proportion remained relatively fixed from then until 1970. From 1970 to 2000, the decisionmaking group grew from 23% to 34% of the workforce, while the clerical and sales group remained, overall, roughly stagnant. As a result, with

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include executive, administrative, and managerial workers, professional specialty workers, and technical and related support workers.

a neat symmetry, the clerical and sales group was about the same fraction of the decisionmaking group at the end of the century as at the beginning.

Creative professionals have grown faster than other managers and professionals. The direct work involved in the creation of new products is, by and large, in the hands of creative professionals. These include the science-based creators, scientists and engineers, of which there are about 5 million, and the culture-based creators, designers, writers, artists, and entertainers, about 2 million more.[8] All told, this group now constitutes about one-sixth of managers, professionals, and technicians, and about one in 16 of all workers.

This group's pay averages about the same as other managers and professionals, that is, about twice that of direct production workers, but as any reader of *Entertainment Weekly* knows, pay within the group is wickedly dispersed. The total payroll of creativity amounts to about 10% of US payrolls. It is the work of this group that is responsible for most of the huge increase in US stock prices over the past two decades: the creations of this group temporarily exempt corporate products from the corrosive forces of direct market competition. As a consequence, products like Harry Potter books, Microsoft Office, Intel Pentium II microprocessors, Viagra, and Disney World can earn billions of dollars of profits.

They had better: for they represent a collective investment of between $500 billion and a trillion dollars annually. US prosperity is based on a high return to that annual investment, so each year corporate valuations will rise by more than a trillion dollars if the investments are, on average,

[8] Professional creative workers consist of architects, engineers, mathematical and computer scientists, natural scientists, social scientists and urban planners, writers, artists, entertainers, and athletes. Minor multiplicative adjustments have been made to exclude teachers of dance, music, and art from the artists and entertainers category in earlier years.

good ones. But that in turn requires that a large proportion of all products must change each year! And that means ongoing turmoil in the workforce.[9]

By contrast, in 1900 there were only 200,000 creative professionals in the workforce, and these represented about 1% of total payrolls. Moreover, without motion photography to capture acting and without sound phonography to capture music, the impact of these creative professionals was much smaller. At that time, culture-based professionals represented two-thirds of the creative professions, and there were only about 60,000 engineers and scientists. So while there was a great deal of change taking place in the early 20th century, with the development of electricity, the automobile, the airplane, movies, phonographs, and radio, the pace at which these inventions impacted the economy was slower, and the proportion of the economy devoted to these pursuits was smaller.

IV. The high school movement (1910 to 1940) and the college movement (1940 to 1970)

Claudia Goldin, an economic historian at Harvard University, has documented the striking fact that before 1900, very few Americans – roughly 10% of the population – went to high school. At that time, high school students often went to private college preparatory programs, and over half of all students went on to college and became professionals – teachers, mainly, but also preachers, lawyers, and doctors.

But as mass production increased, it became clear that corporations needed large numbers of clerical and sales workers to handle rapidly increasing volumes of sales transactions. And these workers needed to have enough understanding of science and mathematics to be able to learn how

[9] Rising productivity has both positive and negative impacts on the workforce. Rising productivity in the US has supported strong and sustained expansion of the economy, and falling overall rates of unemployment, while keeping inflation modest. This cyclical impact has reduced layoffs and stabilized overall employment. On the negative side,

the mass-produced goods operated: how to safely handle electrical appliances, repair cars, replace vacuum tubes on radios, or operate a victrola or a nickelodeon. They also needed to be able to understand corporate forms, tally invoices and customer bills, and follow national events in the newspaper. The information flow associated with the massive quantities of production made possible by mass production techniques required highly accurate hand-recording and responsible transmission of sales data and cash receipts. Clerical and sales workers at the turn of the century were quite well paid, typically earning twice as much as skilled factory workers, so such jobs were looked on as being desirable, both in status and in pay.

A mass movement in favor of publicly supported junior high school and high school education swept the country, particularly the North. Goldin (1998) has pointed out that the resulting increase in the quality of the US workforce helped dramatically increase US output. It represented the major investment in workforce quality America made in the 20th century, far outweighing in quantitative importance the college movement of the postwar period, involving as it did far more of the workforce and increasing the number of years of education more rapidly.

In Chart 6 the rapid climb of high school education is mainly compressed into the period from 1909 to 1939, as the proportion of the population going to high school rose from 13% to 72%.[10]

Moreover, this movement occurred in the US nearly half a century before it did elsewhere in the world. For example, the British, whose university and private school system were probably the most advanced in the world at the time, did not adopt universal high school education until after

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individual corporations and jobs have become riskier, so that the job tenure of workers overall has become more uncertain, for any given level of national unemployment. This has particularly affected experienced male workers.

[10] The enrollment data for primary school include pre-kindergarten and primary school enrollees beyond the 8th grade, which explains why the ratio is consistently over 100 % of 5-13 year olds. Similarly, the data on college enrollment include advanced degree students and older students returning to college, so that is why the ratio is higher than 100 % in 1998.

World War II. The resulting increase in US education not only increased real wages, but the public character of the education resulted in a dramatic increase in US equality.

The economic value of education is the increase in pay that a student can expect from having an additional year of successful formal training. Broadly speaking, that value is determined by supply and demand: how much the demand for educated workers is increasing and how much the supply of educated workers is increasing. If the wage premium for a given level of educational attainment falls while the proportion of such workers increases, then it would appear that the supply of education is keeping ahead of the skill demands of technological progress. On the other hand, if the wage premium rises while the proportion of such workers increases, then skill-biased technological progress is likely outracing the supply of education. (For theoretical discussions and more detailed analyses, see Goldin and Katz, 1999, and Katz and Murphy, 1992.)

In the first decades of the 20th century, the impact of the high school movement was to raise the supply of high school educated students faster than demand. As a result, the economic value of each year of formal training declined, and inequality diminished: the pay gap between the least educated and the most educated fell (Chart 7, Goldin and Katz, 1999).[11]

From 1939 to 1969 the college-going population grew very rapidly. The GI Bill subsidized advanced education in the late 1940s and the 1950s. During the late 1960s, the draft deferment for college students also raised the incentive to go to college. As a consequence, during this period the value of a college education fell, and equality increased again (Katz and Murphy, 1992). But once the college draft exemption was eliminated, the rate of expansion of college-going slowed, and the demand for education caught up. With the electronics revolution, the pace of technological change

[11] The chart shows the impact of four years of high school education, and of four years of college education, on the income of an adult male with 0 to 19 years of work experience.

has risen to an unprecedented pace. So while college-going has reaccelerated, and is increasingly supplemented by advanced education, the education premium has risen (Chart 7).

V. The professional services in an era of creative destruction

The 13 million service professionals include some 4 million medical professionals and 7 million teachers. Virtually all these service professionals have bachelor's degrees and additional formal training after college. Yet they are responsible – in principle – for keeping abreast of an explosion of information relevant to their duties. These occupational groups have very high rates of attending on-going educational courses. In 1995, according to the National Household Educational Survey, doctors, dentists, and veterinarians on average took 2.0 career or job-related courses a year, registered nurses and pharmacists 2.2 courses a year, and elementary and secondary teachers 1.5 courses a year.

The rapid increase in creativity has meant that the amount of potentially useful information has grown extremely rapidly. This offers a challenge to the professional services: can humans keep up with the pace of knowledge?

The answer is that the pace of new products and knowledge production is outracing education. Let us view this dilemma in medicine. Medicine is now the largest industry in the United States, accounting for over a trillion dollars in annual revenues, or more than 10% of US output. The US consumer buys more medicine than food. The pace of progress in medicine is unmistakable and nearly unbearable.

The crisis in medicine. In an editorial published in 1998 in the Journal of the American Medical Association, a blue ribbon team of doctors studying the quality of medicine discussed how doctors were coping with the abundance of new scientific knowledge being produced.

"One crude index of the impact of this change is illuminating. The randomized controlled trial has become the gold standard for evaluating the efficacy of health care interventions of all sorts. Yet it is a relatively recent phenomenon. The first one was published in 1952. In the 30 years from 1966 to 1995, more than 76,000 journal articles were published from randomized controlled trials (as registered in the automated database MEDLINE). The first five years of that period contributed less than 1% of the total, whereas the last half decade contributed more than the previous 25 years combined. In the face of this avalanche of rigorous data on efficacy, our methods of training physicians and other clinicians and our systems for supporting them in the delivery of health care services have not kept pace" (Chassin and Galvin, 1998).

That is, the best trained, best paid, and best informed professionals in America can no longer keep up with the amount of information generated for their patients' benefit. The dimensions of the problem can be seen in the annual averages of published randomized trials. From 1966 to 1970, the years in which the Medicare system was proposed and implemented, randomized controlled trials were published at a rate of roughly 150 articles a year, or three a week. This is a rate of publication that one can imagine a busy but conscientious professional might keep up with. From 1991 to 1995, 150 articles were published every *week.* It seems unlikely that a professional could keep up with this pace of information, even if he or she did nothing else.

The consequence is that the average doctor does not use anything resembling the full armory of medical knowledge in practice. Compared to doctors at the forefront – doctors in teaching hospitals, for example – the average doctor uses a much smaller group of drugs and uses those familiar drugs more intensively. According to Chassin and Galvin (1998), doctors tend to both overuse and underuse medicines.[12]

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[12] In the underuse case, they cite a study of elderly heart attack patients among whom 79 % did not receive beta blockers; the subsequent mortality of these patients at two years was 75 percent greater. In the overuse category, they

One solution is for doctors to draw their prescription and treatment recommendations from a computerized, constantly updated database. At LDS Hospital in Salt Lake City, Utah, such a computer system has been in place for over a decade.[13] Doctors are free to disagree with the computerized recommendation, but if they do so, they must articulate why, and these arguments may result in changes in the computerized recommendation if these treatments are successful. This permits doctors at the frontiers of specialties to improve the computer recommendation and to experiment in concert with other doctors. Several studies of the outcomes at LDS Hospital have shown that the result has been substantially better outcomes at substantially lowered average cost.

Yet outside of a few isolated cases, doctors and hospitals have not adopted computerized systems to improve the handling of cases and the flow of information. Doctors fear, perhaps rightly, that computerization will serve to limit their freedom and may threaten their jobs, since nurses and other medical personnel can also read computer output. Doctors know that the HMOs, hospital chains, and other for-profit corporate providers of medical care will seize any opportunity to cut costs – and computerization of medical diagnosis is a major way to cut costs by reducing the value of doctors.

It is true that medical education in the US is almost surely the best in the world, and new medicines reach our population faster than anywhere else, albeit unevenly. Yet such is the pace of economic change that our medical education and our medical system are not merely inadequate, but in crisis.

Our educational system gets a bum rap because our students do not perform as well on standardized tests as students in many other countries. For example, as Stevenson and Lee (1998) point out, "The only countries that American eighth graders outperformed in both mathematics and

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include studies in which 21 % of antibiotic prescriptions, 17 percent of angiographies, 16 % of hysterectomies, and 20 % of all heart pacemaker insertions were judged clearly inappropriate.

science were Cyprus, Iran, Lithuania, and Portugal...." Yet this same educational system has produced the workers who are the most creative in the world. In terms of preparing students for a world of creative destruction, the US educational system is almost certainly the best. But such are the demands of creative destruction that this system is under attack from all sides. In particular, teachers are struggling to help their students integrate their knowledge and to get better test results.

Learning for a lifetime. The challenges of our economy help explain why students have expectations – whether realistic or not – of obtaining a college education and why countries around the world are moving away from apprenticeship programs.

Creativity. Creating new products is inherently risky. If creating new products that make lots of money were easy, everyone would do it. At the leading edge of innovation, no one knows for sure what the next step is. As Harvard economist Richard Caves puts it, when it comes to creativity, "nobody knows." This requires innovators to be self-confident, able to trust their own judgments, despite what others may be doing or saying. This self-confidence, however, is in practice likely to be continuously undermined because most new products fail. Almost all the profits from new product innovations go to a small handful; in many industries, to less than 10 percent of the new products actually produced (Scherer and Harhoff, 2000).

Creators need the ability to critically evaluate the existing products, decide what additional features or qualities new products should have, and solve the problems that lie in the path of creating the new products and publicizing them to their intended audience. Typically, they need to both communicate with others in their field as they compete with them, and to convince others outside their field of expertise to cooperate in launching the new product. Of course, no one can expect to exemplify all the complex and contradictory mix of skills needed for successful creativity.

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[13] See Garibaldi, 1998, and references therein.

Fortunately, not all of us are required to be creators, just yet: only one worker in 16 is employed at such work. But in the more dynamic work environments we now inhabit, we are asked far more often to change what we are doing, to help in adapting new sets of procedures, and to critique and improve them. Learning from failure is increasingly expected from all of us. Increasingly, educators are suggesting that this can be done with experimental and activist learning along the "constructivist" paradigm in which students actively construct their understanding in their studies.

Supporting experimental and activist learning is not impossible; it is, after all, a natural human activity according to modern developmental psychology. Gopnik et al (1999) have emphasized that human babies naturally experiment and learn like miniature scientists. One of the co-authors of that study, Andrew Meltzoff, argues that to maintain this sort of learning requires school to provides a stress-free environment in which concrete manipulation and active, meaningful exploration is possible (D'Arcangelo, 2000). Offering opportunities for structured play and empowering students to learn to effectively and challenge authority, at the same time as we wish them to acquire large quantities of formal learning requires not only reorienting schools and teachers but also providing substantial new resources for learning.

Perhaps the most important step in the short run is to – insofar as possible – adopt as a value and a goal that *students leave school prepared to successfully continue their education* with recurrent, episodic job- and career-related course training. Traditionally, US education has tended instead to grade students relative to one another, so that typically the slowest learners are labeled as failures.

A frontal attack on this problem would be to attempt to ensure that all students, no matter how fast or slow, have successful learning experiences. Is it possible to do this and still have students learn? An intriguing example of a school reform that supports this approach is reported by Wilson, Corbett, and Williams (2000). They describe a urban middle school that serves a poor community, half African-American and half white. The school instituted a “no excuses” attitude toward the students’ learning. The basic rule adopted was a simple one: “every student would complete every assignment at a level sufficient to get a B. Unfinished and unsatisfactory assignments would be worked on until they were complete and satisfactory, all the while keeping up with new work.”

This program appears to have been reasonably successful, in that on the eighth grade writing assessment the school’s students performed above average for the district, although it served the poorest community therein, and just below average for the state. The math assessment was not reported. As in many educational reforms, it is difficult to assess to what extent the morale of the teachers and the obvious intelligence and enthusiasm of the principal are responsible for this outcome, compared to the specifics of the reform itself.

The crisis in education. Educators are not as well equipped, trained, or paid as doctors. And while it may be true that educational practice has not leapt forward at the pace of medical practice, educators are responsible for preparing their students for a world that in many ways is racing forward more rapidly than medicine. In any case, it is similarly true that almost all educators cannot keep up with best practices. Consider how fast the potential for best practices is rising:

Teachers do not have time to keep up with the computer programs and games available to their students (Roschelle, et al, 2000). While the number of computers per student has risen rapidly, in 1998 only 15 % of teachers had nine hours of training in computer technology or more (Chapman, 2000). English teachers don’t keep up with developments in reader response analysis and its application to the principles of writing (Williams, 1990). Math teachers are unaware of the application of projective geometry – the theoretical basis for 3-dimensional perspective discovered by Renaissance painters – in the development of video games, charts in spreadsheets, and movie and cartoon production. Science labs don't take advantage of hardware to simulate the physical feedback of virtual animal dissection, although that feedback is used in computer joysticks.

Perhaps most important, the prospects for automating the routine of practice and test-taking in education remain bleak. Giving students computerized desks in principle could allow teachers to give and grade tests frequently and with scant effort. But we are far from being able to reach this standard. Not only is teacher training inadequate, but the hardware resources – despite a substantial investment – are outdated (most of the computers available to students are not multi-media computers) and the software offerings lacking.

For example, electronic automation of data processing is now routine in most American corporate offices. Tests on arithmetic, spelling, reading, geographic and science facts, and the like could be both more informatively and less costly in terms of teacher and student time if done over a computer network. By downloading the results, programs could pinpoint student weaknesses, both individually and en bloc. It would also permit teachers to perform controlled experiments, to test the effectiveness of alternative lesson plans in instilling particular kinds of information. In turn, this documentation could allow teachers who produce new, more effective teaching methodologies to be identified, the methodologies shared and further tested and refined, and the originating teachers rewarded for their contributions to teaching.

Such computerization might also permit the detailed diagnosis and assessment of learning disabilities and problems in individual students, which, in turn, would lay the basis for detailed discovery of methods for solving learning problems and catering to disabilities. Successfully applied, this could result in a system in which learning speed became less crucial to a student's ability to complete a given level of education. That would be an important step forward given that the work world increasingly demands that all workers – not merely the top ones – be sufficiently comfortable with formal education to be willing to pursue it throughout their work lives.

Yet few educational systems have embraced this level of computerization. The software tools have been slow to develop, and few schools have committed themselves to placing computers on every student's desk. Of particular concern is the fact that relatively little funding has gone into assessing the strengths and limitations of individual learning technologies (Shields and Behrman, 2000), although overall studies suggest that computer technologies are useful both in drill (a meta-analysis is performed in Kulik, 1994) and in deepening mathematical understanding (Wenglinsky, 1998, a large scale national study).

Moreover, it is quite possible that many teachers will resist an intensive computerization of learning, both because of the revision to their own work habits and accumulated knowledge that this would require and because of the likelihood that these evaluative tools would be used on the teachers as well as the students. These tools would permit detailed evaluation of the ability of individual teachers to improve the knowledge of their students and could be used as a blunt instrument for forcing teachers to focus on short-term results at the cost of more intangible skills.

At the same time, many teachers are not trained to help their students develop the skills they already possess that could be the basis for their education. To give one example, music, art, and dance are areas in which at least limited curricula have been developed that help students use these activities to understand concepts in math, science, language, and history. But the average non-specialist teacher is not able to teach music, art, and dance, areas where students' abilities often outstrip their own. It may be possible one day for distance learning to fill the gap.

More generally, though, just as the bulk of a doctor's knowledge and power is in the routine part of medicine, so too is a teacher's. If computers take over the routine of education, then teachers must become something more – a role that many teachers, like doctors, may be uncomfortable with.

Ultimately, it may be possible to foster learning through many channels. Our work system is pushing the entire workforce toward being either creators or those who cooperate with creativity, because the machines we use to produce goods and services increasingly don't need human input. If this is the case, then the role of the teacher will be more and more about fostering creativity, communication, and cooperation, rather than the specific learning of specific pieces of knowledge, such as how to form a letter or multiply fractions.

One avenue for training for creative destruction that has already spread to many school districts is training in peer mediation and conflict resolution. While such training is often aimed at resolving potentially violent conflicts, training in negotiation is of value in a broad spectrum of circumstances. In particular, it is useful in an economy of creative destruction. Conflict is central to creative destruction, because new ideas are inherently conflictual. Most new ideas turn out to be wrong; most new products lose money. How to give potential new ideas a fair trial, and how to separate what is sound about a new idea or product from what is not, involve conflicts that must be resolved and mediated with as little damage to egos and budgets as possible. Helping students learn techniques for rational negotiation and how to help others attain their goals without harming one's own is likely to prove a fundamental building block for a career in the age of creative destruction.

VI. Conclusion

Over the course of the 20^{th} century, the US has evolved from a country where few students went beyond the primary grades to one where most students enter college. The century has witnessed enormous change, but the pace of change appears likely only to accelerate. Already we have reached the point where all workers must look forward to a lifetime of continuing education.

Just as the education of doctors has not prepared them for the pace of change the medical profession is experiencing, so too the education of teachers has not prepared them for the pace of change the educational process is experiencing. It is hard to prepare students for a lifetime of continuing education, and it is even harder to prepare students for a lifetime of creativity.

It is possible that eventually electronic advances may make it more possible for educators to meet these challenges; in the meantime, dissatisfaction with education and educators is likely to deepen. Learning techniques of conflict resolution may be helpful for teachers and students alike.

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Sources for data in charts:

Charts 1 and 2: National Center for Education Statistics, *Digest of Education Statistics, 1999*, Table 384.

Charts 3, 4, and 5: 1900-1970, Department of Commerce, *Historical Statistics of the United States, Colonial Times to 1970*. 1980, Census Bureau, *Census of Population, 1980*. 1990 and 1998, Bureau of Labor Statistics, *Employment and Earnings*, January 1991 and January 1999.

Chart 6: National Center for Education Statistics, *Digest of Education Statistics, 1999*, Table 3, Department of Commerce, *Historical Statistics of the United States, Colonial Times to 1970*, and *US Statistical Abstract, 1999.*

Chart 7: Goldin and Katz, 1999, Appendix.

Chart 1: Occupations of Workers 25 and Older with Given Educational Achievement

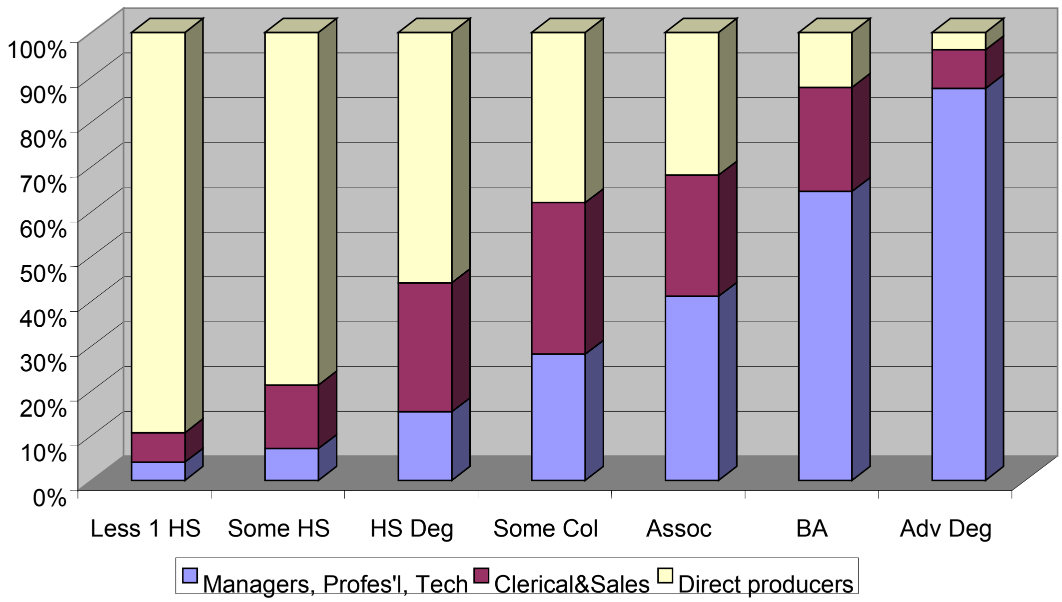
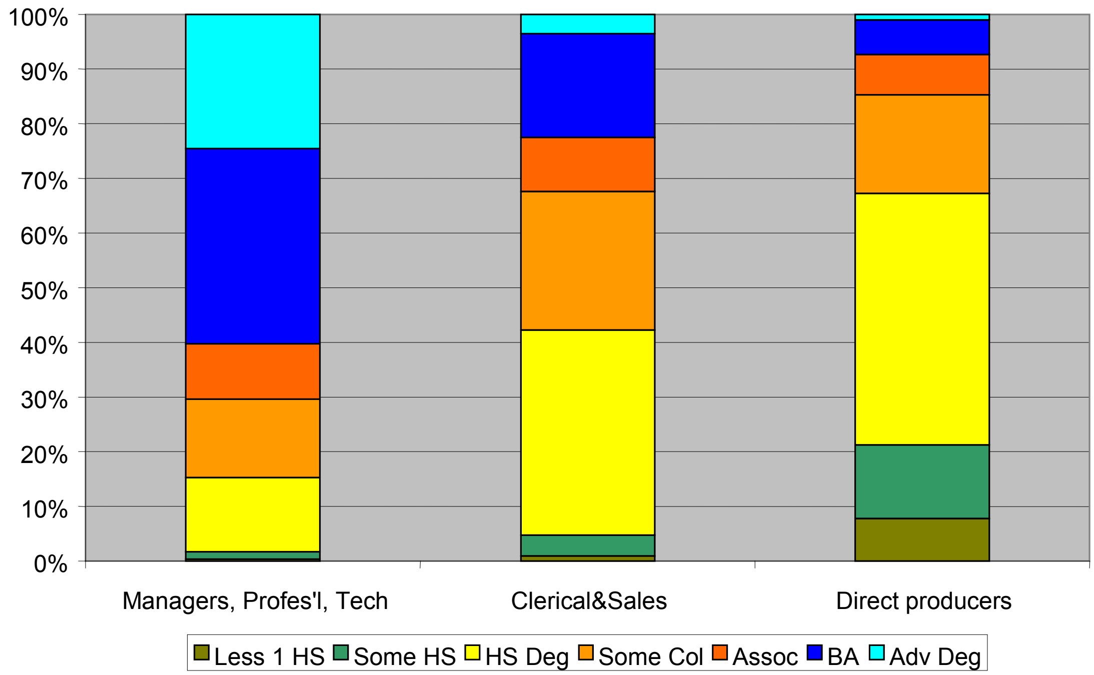


Chart 2: Occupations by Educational Background



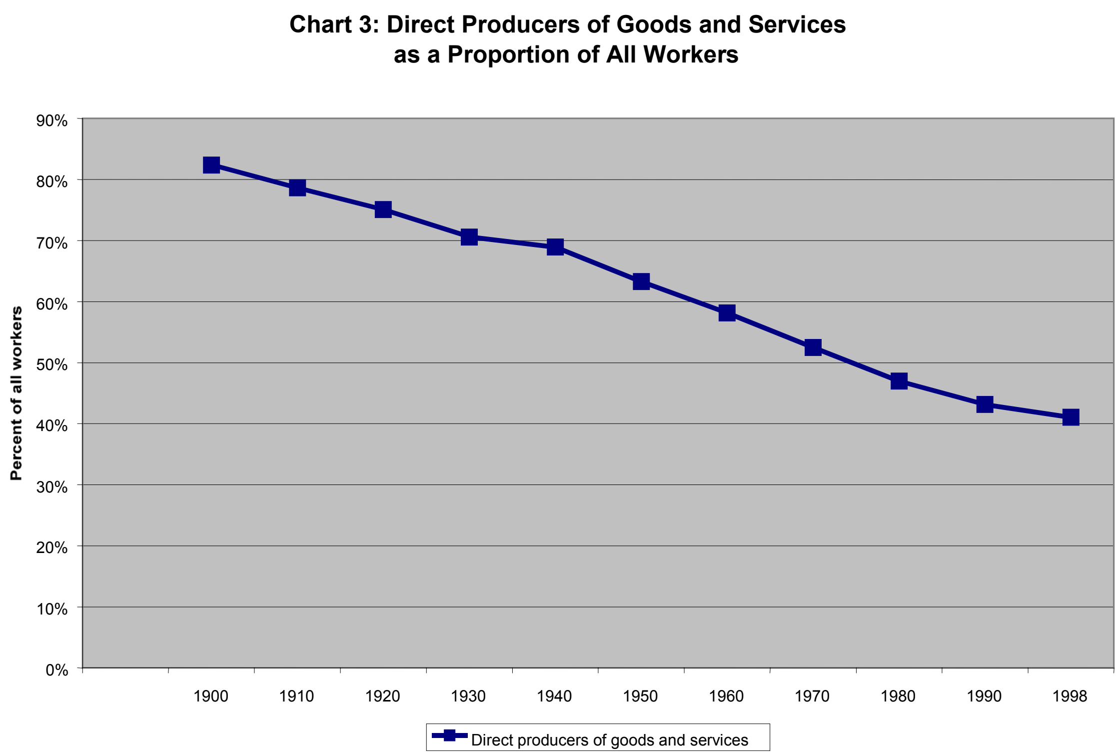


Chart 3: Direct Producers of Goods and Services
as a Proportion of All Workers
Percent of all workers
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
1998
Direct producers of goods and services

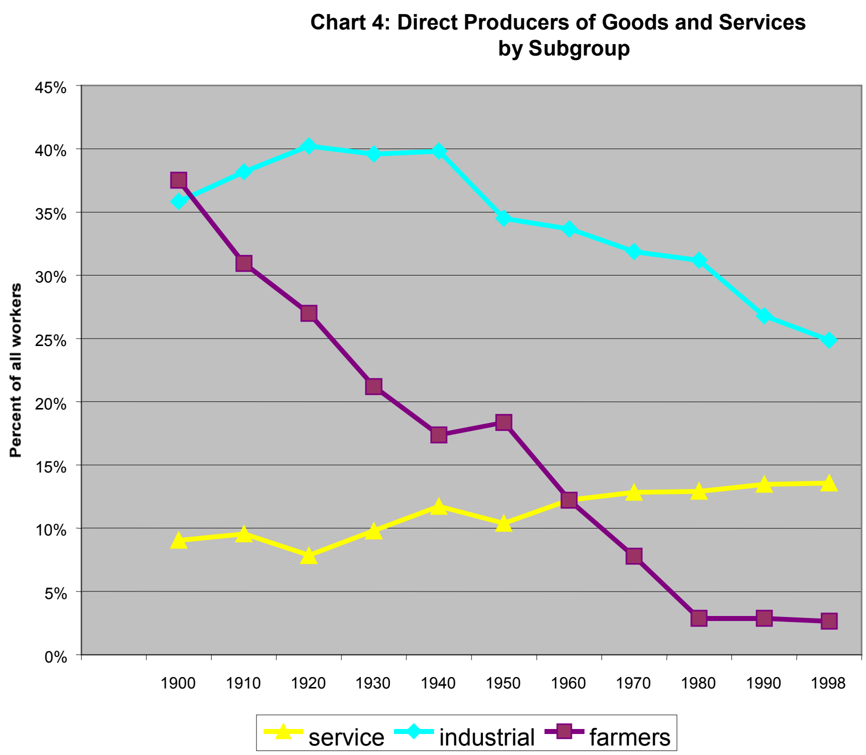


Chart 4: Direct Producers of Goods and Services
by Subgroup
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percent of all workers
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
1998
service
industrial
farmers

Chart 5: White Collar Workers

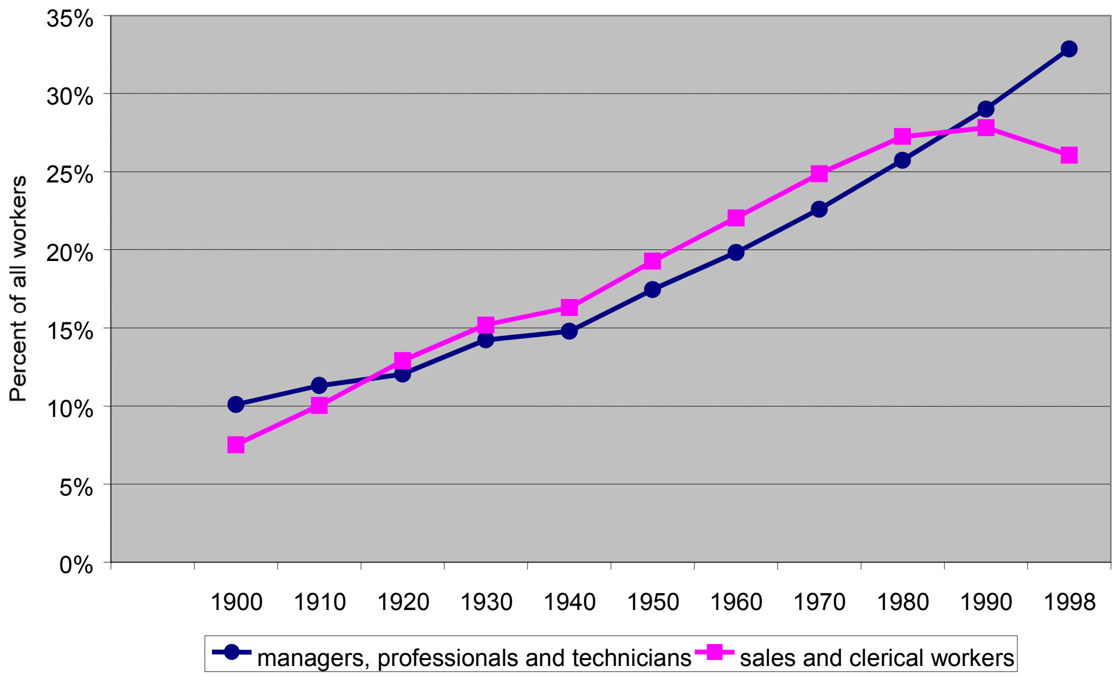


Chart 6: School Attendance Rates

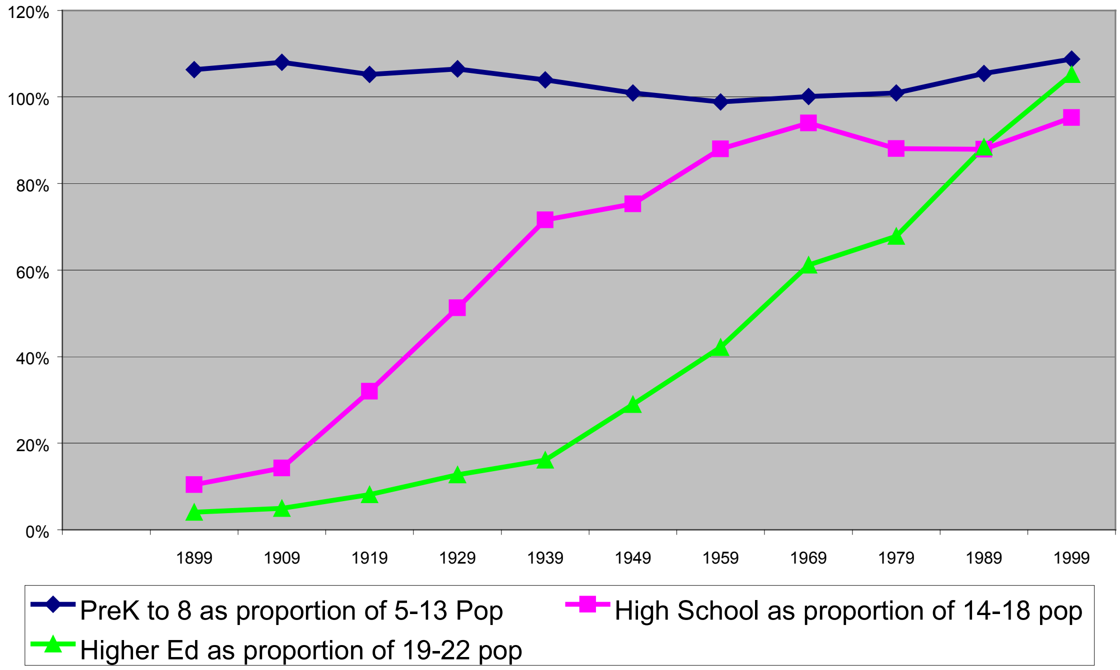


Chart 7: Increase in Pay for Four Years of Education