Invention, Technology, and the GI Bill

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Abstract

The era of industrialization was also the age of invention, which spurred technology that in turn required skills not provided by existing educational institutions. In particular, the traditional elite higher education centers could not, or would not, provide the training in the numbers needed for a technical and increasingly global economy. The GI Bill in the United States changed this entirely, making higher education available to 2.2 million veterans returning from WW2: few of these had previously the chance of a university or college education. The economic benefits to the United States were immense.

From community college to university, higher education enrollment burgeoned, so that by the new millennium two thirds of high school seniors expected to get a bachelor's degree. Other countries, including Britain, followed suit. Given this it is difficult to understand the impact of C.P. Snow's "Two Cultures" argument about a cultural divide between a tiny cohort of cultural intellectuals and scientists, since at best it was a generation too late to be relevant and at worst focused on an increasingly irrelevant, class-based society.

I The Age of Invention

Thomas Savery, the English military engineer, designed and built a crude and inefficient steam engine around the year 1700 to pump water out of coal mines: his design was a large, sealed, water filled kettle heated externally to change the water into steam. In 1712 Thomas Newcomen's improved engine used steam to drive a reciprocating piston in a cylinder to produce power, but his engine was very inefficient since the cylinder had to be successively heated and cooled just as Savery's kettle. It took the Scottish inventor James Watt to build a much better engine that allowed the steam to be condensed separately from the cylinder so the cylinder could remain hot and be in constant use; he received a patent for this in 1769. A schematic of this engine is shown in Figure1.

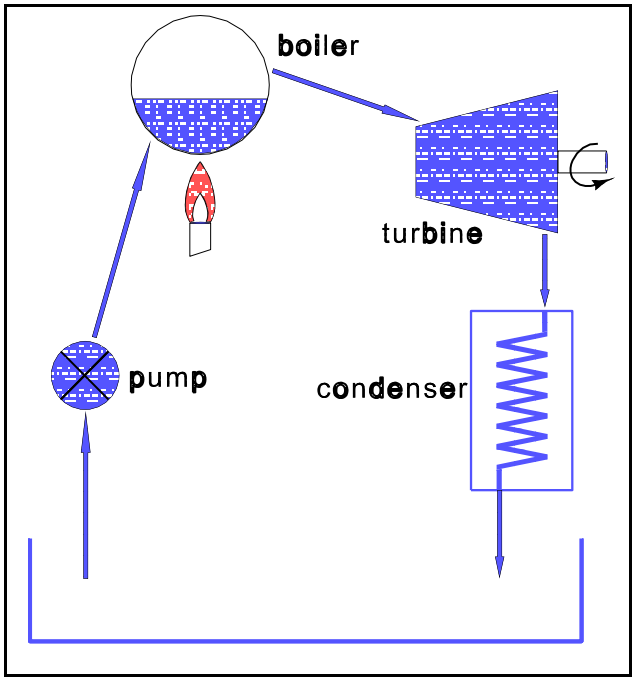
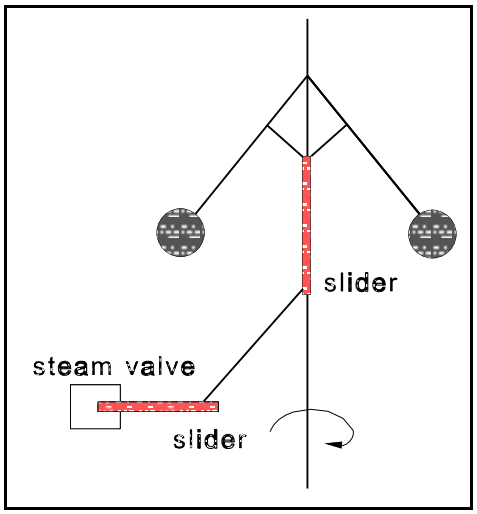


Figure 1: The Watt Steam Boiler/Turbine



What was lacking in the design of these steam engines was an effective method of speed control. This problem was eventually solved by James Watt with the centrifugal flywheel governor shown in Figure 2. What then became available was a reliable engine whose output was a rotating shaft at controlled speed from which power could be drawn to drive machinery, using the most plentiful source of energy in England—coal. So, the original steam engine was developed to get at coal, and eventually coal was needed for the steam engines to power the machinery in the factories that made textiles.

Figure 2: The Watt Centrifugal Governor

The development of the steam engine is a classic case of the process of invention, from need to design to experimentation to improvement.

> "The greatest invention of the nineteenth century was the invention of the method of invention.... In order to understand our epoch, we can neglect the details of change, such as railways, telegrams, radios, spinning machines, synthetic dyes. We must concentrate on the method itself; that is the real novelty, which had broken up the foundations of the old civilization [Whitehead, 1925]."

The English patent system provided greatest impetus to invention. Patents were instituted in the 17th century following pressure on the Monarchy of England to limit the granting of monopolies: a side effect, perhaps not originally intended, was the demise of the Closed Shop Guild whose purpose was to maintain a commercial advantage by keeping processes a secret, with the result that technical advances came slowly.

Before the patent system the Crown could remove from the general population a right they previously enjoyed and grant it to an individual. For example, the right to import salt could be controlled through a monopoly. Under democratic pressure the Crown issued `Letters Patent' to inventors as evidence of the rights that inventor had to an invention. The system grew and became a standard part of the law of the land in the next 150 years. It was this system that was brought to the new world by the colonists. Article I, Section 8 of the Constitution of the United States:

> "The congress shall have the power ... to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

A patent is a grant issued by the government of a country or confederation of countries giving the inventor or his/her assigns the right to exclude all others from making or profiting from his/her invention within that country or countries. In the United States the term of this patent is 20 years from the time of application; this term cannot be extended except by act of Congress. The purpose of the time limitation is to permit the inventor time in which to profit, but to bring the invention into

the public domain after the 20 year monopoly period so all can benefit. Once the patent expires, the exclusive right to make and profit from the invention is gone.

New inventions and discoveries are rarely isolated occurrences, and the process of invention described by Whitehead has been followed by the processes of design and manufacture, resulting in an accelerated development cycle and intense market place competition. Now, with the rapid dissemination of technical information, the possibility of near simultaneous invention is increasing. It was possibly for this reason that US Congress is considering changing America from a `first to invent' state to a `first to file' state, in line with the rest of the world.

If one particular inventor did not patent an idea, in all probability some other would do so in a short period of time. Further, even when a process is not identified but the result is evident, this can spur the development of a similar or identical process - the fact that atomic bombs were dropped on Japan made it inevitable that the USSR would develop the technology.

Although the transistor was invented at Bell Telephone laboratories in 1948 by physicists John Bardeen, Walter H. Brattain and William Shockley (their two most important patents were #2,502,488 and #2,524,035, which led in 1956 to the Nobel prize in physics), two German physicists Herbert Mataré and Heinrich Welker were developing the same device while working at the Westinghouse Laboratory in Paris, and it was only a matter of time before they were successful.

Knowledge of semiconductors began around the beginning of the twentieth century. G.W. Prichard received patent #836,531 in 1906 for a silicon point-contact diode. One would expect a fairly rapid development involving slapping two diodes together and adding another contact to make a transistor, but instead the work on the vacuum tube by Lee de Forest delayed this logical development until after WW2: used in amplification, the vacuum tube became the principle engine of radio and television, and in 1945 was the heart of the first high-speed digital computer called ENIAC.

II The Age of Technology

An invention has value when it is made into a device that someone finds useful. A patent for a better mousetrap is useless if it cannot be made. The key to making real money from an invention is to manufacture it in substantial numbers. Manufacture needs a technological infrastructure. “In the eighteenth century, a series of inventions transformed the manufacture of cotton in England and gave rise to a new mode or production -- the factory system... The abundance and variety of these innovations almost defy compilation, but they may be subsumed under three principles: the substitution of machines - rapid, regular, precise, tireless - for human skill and effort; the substitution of inanimate for animate sources of power, in particular, the introduction of engines for converting heat into work, thereby opening to man a new and almost unlimited supply of energy; the use of new and far more abundant raw materials, in particular, the substitution of mineral for vegetable or animal substances." These improvements constitute the Industrial Revolution [Landes, 2003], and can be encapsulated by the structure shown in Figure 3.

Figure 3: The Industrial Process

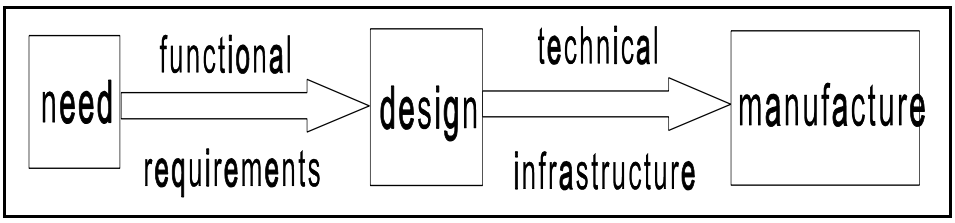


Figure 3: The Industrial Process

The advantage that England enjoyed over the rest of the world was fleeting. Francis Cabot Lowell, after carefully observing mill operations in England (considered by some an act of industrial espionage) formed the Boston manufacturing Company in Waltham, Massachusetts in 1813, and then expanded to Lowell in 1822. It is interesting that when Charles Dickens visited America in 1842 he wanted to be taken to the industrial wonder of Lowell.

Water power was one reason for choosing Lowell and other mill locations on Massachusetts. Another reason was the availability of educated (by standards of the day) daughters of local farmers who were desperate to leave the drudgery of farm life behind.

Water power was harnessed by turbines, and these needed technology in their manufacture. Until the invention and mass production of the internal combustion engine, waterpower was king. In the US South, cotton was king, but was shipped to New England to be manufactured. The development of the internal combustion engine, and the discovery of oil in Pennsylvania to fuel that engine, enabled the cotton to be processed close to source. The New England mills were not necessarily doomed, but short sighted and greedy actions by the mill owners led to lack of innovation and industrial job actions. Now, few mills survive in the North East.

The key to industrial survival is to keep ahead of the competition. Yesterday's great product could be tomorrow's commodity and the day after's dodo. The race to stay ahead is epitomized by the title of the 1996 autobiography of Andrew S. Grove, co-founder of Intel Corporation, the world leader in the manufacture of processor chips for PCs - "Only the Paranoid Survive"[Grove, 1996].

A major factor in keeping ahead of the competition is to anticipate, or at least rapidly assimilate, new technology. History is replete with examples of leaders who failed to follow this edict:

"What use could this company make of an electrical toy" [Western Union president William Orton rejecting Alexander Graham Bell's offer to sell his telephone company for $100,000]; Western Union still survives as a telegraph operation of little importance.
“Everything that can be invented has been invented.” [Charles Duell, U.S. commissioner of patents, 1899].
“Radio has no future.” [Lord Kelvin, president of the Royal Society, 1897].

III Exploitation and Democratization

The industrial revolution in England was an era of opportunity and exploitation. The drudgery and poverty of the farm were replaced with the soot, monotony and mobility of factory life. The rewards were not fairly distributed, but the tethers to the farm were broken for ever. In the nineteenth century in England, and United States in particular, mill owners became greedy in the belief that they had a God-given right to wealth and the workers stood in the way. Wages were reduced, and working conditions became appalling. In particular, child labor was the ultimate cheap labor, and abuses of children became scandalous. In the 1833 report "Effects of Factory Labour on Children" by a British government commission includes appalling testimony, of which this is an example:

"Many a one I had to rouse when the work is very slack from fatigue; the children very much jaded when worked late at night; the children bore the long hours very ill indeed; after working eight or nine or ten hours, they were nearly ready to faint; some were asleep; some were only kept awake by being spoke to, or a little chastisement to make them jump up; I was obliged to chastise them when they were almost fainting, and it hurt my feelings; then they would spring up and work pretty well for another hour; but the last two or three hours was my hardest work, for they got so exhausted."

Conditions were no better in America. A pamphlet entitled "State of Education, With Particular Reference to the Effect of Manufacturing, on the Health and Happiness of the Poor," published in New York in 1834, catalogs the degradation, even slavery, of the factory worker. Describing what may be seen in American factories:

"He might see in some, and not infrequent instances, the child, and the female child, too, driven up to the clockwork with the cowhide, or the well-seasoned strap of American manufacture. We could show him many females who have had corporeal punishment inflicted on them; one girl, eleven years of age, who had her leg broken with a billet of wood; another who had a board split over her head by a heartless monster in the shape of the overseer of a cotton-mill [Fielden, 1969].

One experiences dé jàvu in reading Fielden's descriptions of the reasons given by the mill owners for insisting on a fifteen hour workday - `foreign competition', `our competitors work that long time'. Fielden identifies the reason for England's competitive advantage:

"Our geographic position, our climate, our mines and minerals, and the dexterity and perseverance of our workpeople, to say nothing of the superiority of our machinery, give to England advantages which she always has and always must possess over any other manufacturing nation in the world."

Unfortunately, this competitive advantage was dissipated by stupidity (America became the

dominant inventive power in manufacturing when few attempts were made in England to nurture the technology of manufacturing) and greed (the workers were exploited and children neglected right up to the Second World War, a situation that effected the capabilities of the fighting man).

The middle of the nineteenth century saw child labor laws enacted in Britain and America. Further laws limited the working day for adult workers. For example, the Ten Hour Bill was passed in Britain in 1833.

In all industrial countries, workers organized into unions; their major weapon was the right to withhold labor, to strike, and to prevent scabs (non-strikers) from crossing the picket lines. However, nineteenth century courts of law commonly sided with the mill owners and against constitutional guarantees and common sense. In 1815 a Philadelphia court ruled against journeymen shoemakers, saying "A combination of workmen to raise their wages may be considered in a two-fold point of view; one its to benefit themselves ... the other is to injure those who do not join the society. The rule of law condemns both" [Rayback, 1966]. Labor strife continued throughout the nineteenth century on both sides of the Atlantic. Union members and leaders were even executed on the flimsiest of evidence; see the Haymarket Square affair of 1886 [Rayback, 1966].

The modern era of the labor movement can be traced to the formation of the AFL (American Federation of Labor) in December, 1886. With the new century, the political climate became better for labor, and a succession of legislation beneficial to labor was passed. The application of the Sherman Anti-trust law of 1897, a sweeping piece of legislation that effectively outlawed all associations, was undone by the Clayton Act of 1914, which contains the statement "The labor of a human being is not a commodity or article of commerce. Nothing contained in the anti-trust laws shall be construed to forbid the existence and operation of labor ... organizations, instituted for the purpose of mutual help."

World War I was a good time for the labor movement in the United States:

> "The benevolent attitude that the Federal Government displayed towards labor during the war undoubtedly worked in favor of the trade unionists. The government fostered a spirit which encouraged increases in wages, decreases in hours, and better working conditions. War conditions in turn gave substance to the spirit. The war created an abnormal demand for labor; at the same time it made labor scarce by reducing migration to practically nothing and by removing 4,000,000 men from the ranks of actual or potential labor and placing them in the armed services. The need for labor led industry, which was itself making huge profits, to raise wages.... The First World War ended with the AFL in a jubilant mood [Rayback, 1966]."

The Great Depression was succeeded by the Roosevelt administration with its benign attitude towards labor. The CIO (Committee for Industrial Organization) was formed during the first Roosevelt administration to counter what was perceived as AFL ineptitude, and soon organized the automotive industry in America under the title the UAW (United Autoworkers Union). Management opposed the UAW, and even hired thugs to beat-up union members. The bitterness of these early days effected the judgement of the union leaders after the Second World War, even after the wage scales paid to their members were higher than their skill levels and counterparts in other industries justified.

The absence of labor disputes in Japan were attributed to the Japanese character, rather than working conditions and procedures. With the experience of Japanese automobile plants in US and Britain we now know better. The Japanese use empowered teams of workers and a sparse management structure, so the worker is made to feel important rather than an insignificant cog in an impersonal wheel.

At the beginning of the nineteenth century over 90% of adult Americans were engaged in agricultural work, and we had difficulty in feeding ourselves. Now, a little over 2% of the American workforce is in agriculture, and we produce more than we need: we provide cash incentives for farmers not to grow things. A time-line of the dominant employment is shown in Figure 4. The analogy to manufacturing is important. To agonize over declining manufacturing employment is about as effective and useful as King Canute standing at the water's edge and willing the tide to stop.

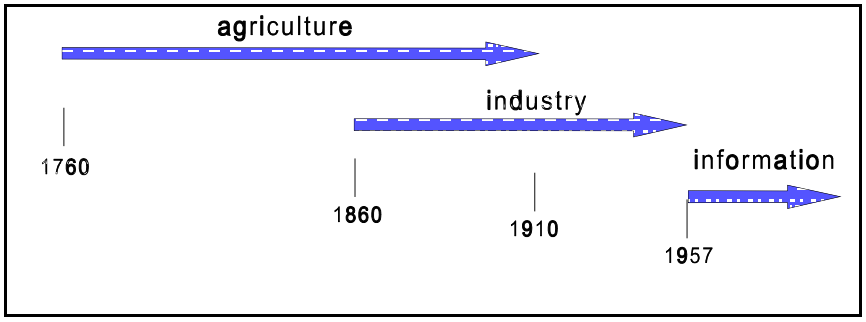


Figure 4: A Tine-Line of Dominant Employment

The farm tractor enabled the farmer to increase productivity by orders of magnitude and displace agricultural workers, who drifted towards the cities and became unskilled industrial workers [Naisbitt, 1982]. Now, the need for unskilled workers in our factories is dropping and will continue to drop, and the service sector can only absorb so many, and usually in low wage jobs.

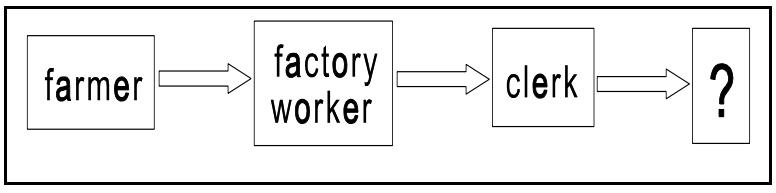


Figure 5: From farmer to ?

We have moved from eras in which farming was the dominant activity, then industrial laboring, then clerical. In the last twenty years the computer has become the technical equivalent of the farm tractor. Banks of clerks and bookkeepers are being replaced with a PC or two. As illustrated in Figure 5, where will people be employed when clerical employment is about the same as farm employment?

IV Educating the Workforce

The skills of the workforces needed for Britain and United States to remain competitive in a global economy are the same - communication and math/science skills. Communication requires effective verbal and reading/writing skills. For example, an necessary skill for an employee to have is to be able to comprehend instruction and to identify and communicate problems: the identification is a technical skill most likely based in a mathematical or science background. None of the qualifications needed include an appreciation of Chaucer, Coleridge or Chopin, desirable those these may be for one's soul or in polite company.

The universal education model of the United States is a relatively recent phenomenon. In 1900 only about ten percent of students aged 14-17 were enrolled in school. This increased to about 70% by 1940, and was close to 100% by 1980 [National Center for Education Statistics, 2006]. A history of school enrollments for ages 14 through 17 is shown in Figure 6.

It was the Servicemen's Readjustment Act of 1944, popularly known as the GI Bill, in the United States that provided the death knell for the class system that enabled intellectuals such as C.P. Snow to define a non-existent battle. 2.2 million returning soldiers, sailors and airmen, 51% of those eligible, took advantage of the GI Bill to enter college, most of them the first in their families to have the opportunity for higher education. The maturity and motivation that these students brought made them the best, and the rewards to the country were manifest.

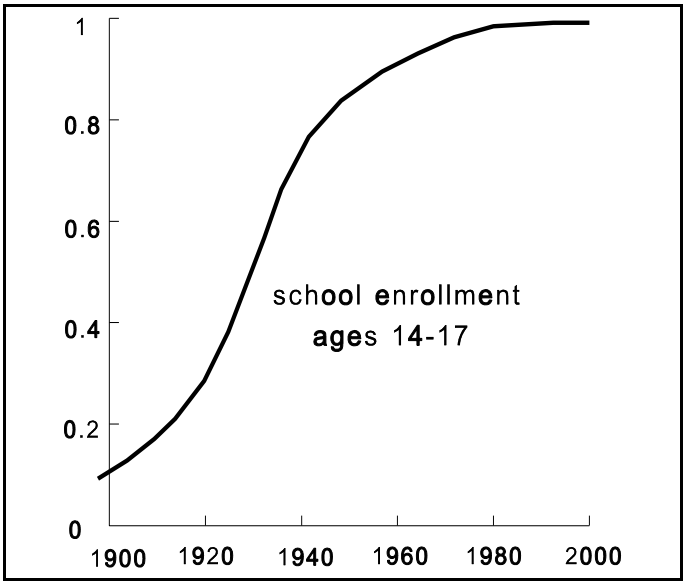


Figure 6: History of School Enrollment in USA

Interestingly, many college presidents were opposed to this influx. James Conant, President of Harvard, opposed the bill since it failed "to distinguish between those who can profit most by advanced education and those who cannot". Robert Hutchins, President of the University of Chicago complained "colleges and universities will find themselves converted into hobo jungles".

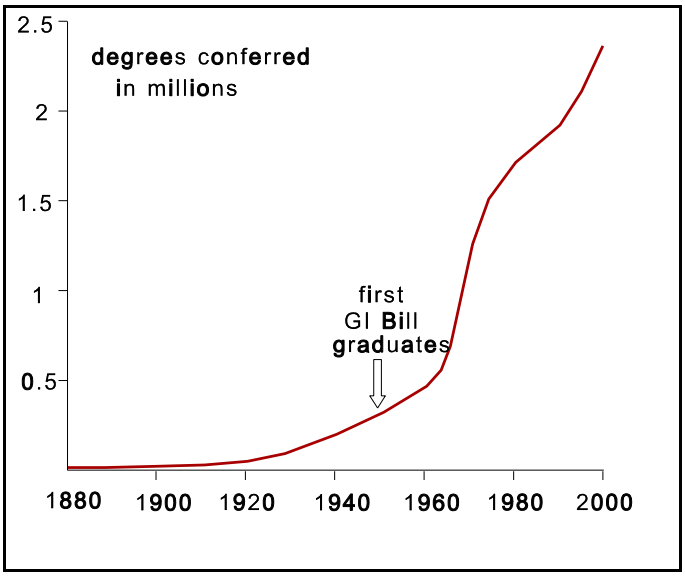


Figure 7: History of Degrees Conferred in USA

The GI bill roughly doubled enrollments in higher education by 1952 over pre-war figures. College enrollments were about 1.5 million in 1940, but rose to 2.3 million in 1950 and shot up to 4.1 million in 1960. The boost in college enrollments as reflected by graduation rates is shown in Figure 7: notice the arrow indicating the start of the first GI Bill graduates. By 1975 about a half of the college age population was enrolled, and by 2005 almost 21 million students were in higher education in the United States, of which about 7 million were in science or engineering [National Center for Education Statistics, 2006].

There were five GI bills, the first being the one in 1944. All have been a great success. Unfortunately, the bills provide for constant dollars, not adjusted for inflation, so now the benefit for returning veterans of the Iraq and Afghanistan wars is much reduced. The lead editorial in the New York Times on Memorial Day, 2008, was entitled `Mr. Bush and the GI Bill'. It supported a new GI Bill that would provide the same educational opportunities for returning veterans from Iraq and Afghanistan as those returning from WW2. The bill has strong support in Congress. It describes the original GI bill as "one of the most successful benefits programs - one of the soundest investments in human potential - in the nation's history." The editorial rails against President Bush who threatens to veto it on the grounds that it is too expensive ($52 billion over 10 years, a small sum compared to Bush's multi-trillion dollar Iraq debacle) and would decrease re-enlistments.

V Goodbye Tradition!

The traditional English model of Oxford/Cambridge, requiring entering students to be proficient in Latin and Greek, restricted entry to a privileged few. It was within this cohort that Snow defined the culture war, where on one side the cultural intellectuals wilfully refused to know about anything scientific, and on the other side were blinkered scientists absorbed in their own narrow world. This quote [Forester, 1945] caricatures the cultural divide:

> "You are a master of all trades, Richard."
> "Not of yours, Hornblower, I'm afraid. Never could learn all those ports and starboards and back-you-lees and things of that sort. One has to learn those as a schoolboy, like *hic, haec, hoc*."
> It was hard to prick the Marquis's sublime complacency.

C.P. Snow defined the divide with these two quotations: "I believe the intellectual life of the whole of western society is increasingly being split into two polar groups ... at one pole we have the literary intellectuals ... at the other scientists. Between the two a gulf of mutual incomprehension... "I have given reasons why I think [educating in one academic skill] is a disastrous process, for the purpose of a living culture. I am going on to give reasons why I think it is fatal, if we are going to perform our practical tasks in the world." Unfortunately, the reasons given are not convincing.

The GI Bill let the genie out of the bottle so now higher education is accessible to all. The cultural divide is gone, never to return. It is a pity that Snow could not recognize that the problem he sought to define was ephemeral, soon to pass:

> "Snow's ideas are clearly dated (his view of science and the arts was formed at Cambridge in the 1930s), and his viewpoint is very simplistic in places (his somewhat naive assumption of the ability of science to solve the world's problems is perhaps the most notable). Any communication problem between the arts and the sciences is now subsumed by a much more general fragmentation of human learning, a fragmentation which is actively lauded by many" [Yee, 1993].

However, Snow did recognize the changing circumstances of post WW2 Britain in these quotes from "The Two Cultures":

> "It is not only that the young scientists now feel they are part of a culture on the rise while the other is in retreat. It is also, to be brutal, that the young scientists know that with an indifferent degree they'll get a comfortable job, while their contemporaries and counterparts in English or History will be lucky to earn 60 per cent as much... If we forget the scientific culture, then the rest of western intellectuals have never tried, wanted, or been able to understand the industrial revolution, much less accept it. Intellectuals, in particular literary intellectuals, are natural Luddites... Almost none of the talent, almost none of the imaginative energy, went back into the revolution which was producing the wealth. The traditional culture became abstracted from it as it became more wealthy, trained its young men for administration, for the Indian Empire, for the purpose of perpetuating the culture itself, but never under any circumstances to equipped them to understand the revolution or take part in it. Far-sighted men were beginning to see, before the middle of the nineteenth century, that in order to go on producing wealth, the country needed to train some of its bright minds in science, particularly in applied science... The curious thing was that in Germany, in the 1830's and the 1840's, long before serious industrialization had started there, it was possible to get a good university education in applied science, better than anything England or U.S. could offer for a couple of generations."

The traditional British view of scientists is that they are not competent to be leaders of others. During the Second World War, British military leaders and politicians when confronted with a major problem, such as the magnetic mine threat to allied shipping, referred the matter to `the boffins'. The boffins were engineers and scientists who were tucked away in laboratories to be activated when called upon, and dismissed to their quiet worlds after they delivered the solution. "The word conjures up an image of men in thick spectacles and white lab coats, obsessively working with complicated apparatus. Portrayals of boffins emphasize their eccentric genius and their naive ineptitude in social interaction [Wickipedia] ." These engineers and scientists rarely acquired power or influence. One can trace the post war decline of the manufacturing base of Britain in part to the exclusion of the best brains, with skill sets that were enviable to the rest of the world, from the corridors of power. Many formed the brain-drain to Australia, Canada and the United States.

In C.P. Snow's England, class commonly meant family background and connections. Entrance to Eton/Harrow were all but guaranteed a future place in Oxford/Cambridge, and even a gentleman's C there was good enough to get a junior executive position in commerce. Even those without the connections had aspirations:

I'm Burlington Bertie I rise at ten thirty
Then saunter along like a toff
I walk down the Strand with my gloves on my hand
Then I walk down again with them off

(Part of lyrics from Burlington Bertie from Bow)

Class is now defined by wealth. Movie stars can make big money, while repertory theater actors are near the bread line. J.K. Rowlings may be fabulously wealthy due to her Harry Potter series of books, while the vast majority of writers struggle to make a living. Michael Jackson's album "Thriller" was released in 1982, and in the year after its release its sales exceeded the sales of all the classical music albums in the world combined. Pop stars are very rich, while classical musicians typically struggle financially.

VI Hello Mediocrity!

There is much to applaud about the democratization of education. It has opened doors to anyone with ability and ambition. However, there is a down side to the universality of higher education. It is the decline of academic standards in the high schools of America. The mantra `every child has a right to a high school education' has devolved to `every child will get a high school diploma provided they stay in school'. Teachers are required to reduce the pace so the slower students can keep up, with the result that expectation levels are low and skills necessary for higher education, particularly in communication, mathematics and science, are often lacking. These indifferent and inadequately-prepared students flood college and university classrooms: with the exception of the elite universities, retention is often low.

Further, as the native population has stabilized or is in decline, both in America and Britain, the present and future growth in both countries comes from immigrants, both legal and illegal. In

America the white population is predicted to decline from 82% in 1980 to 63% in 2020, so the minority population will double over the same time period. In 2000 the percentages of each demographic group with a bachelor or higher degree was 46% for Asian-Americans, 30% for white Americans, 15% for African Americans, and 11% for Hispanic Americans.

> "If current trends continue, the proportion of workers with high school diplomas and college degrees will decrease and the personal income of Americans will decline over the next 15 years... The projected decline in educational levels coincides with the growth of a knowledge-based economy that requires most workers to have higher levels of education" [Anon, 2005].

About 15% of young adults in America are neither employed nor in school. In 2003 about 28% of 8th grade students scored below the basic reading level and 33% scored below the basic mathematics level. About 30% of high school students failed to graduate, and nearly 50% of minority students fell behind their native peers. This at a time when 75% of new jobs require skills beyond that provided by high schools: see www.clasp.org/CampaignForYouth/PolicyBrief.
The WW2 veterans who took advantage of the GI Bill were, by today's standards, poorly prepared for higher education, so how was it that they performed so well in college? The answer is maturity and motivation. One cannot blame youth in this third millennium for lack of maturity, but one can certainly blame them for lack of motivation. We are in this MTV era of instant gratification, when the dedication and perseverance needed to master a subject are often missing.

It is evident that high school graduates are less competent than their parents. Much more than the skills for a job in the modern economy is missing in today's graduates. Many, including this author, deplore the diminution of the cultural climate in America.

Conclusions

The perception of a cultural war is over. The universality of high school education, and the near ubiquitousness of higher education as a result of the GI bill, sped its demise. The cultural elites now enjoy their art on their own time as there is little place for it in business or commerce. The ability to communicate accurately and succinctly by e-mail is more important than quoting Shakespeare. However, a downside to this democratization, besides a diminished appreciation for the arts, is a trend towards dumbing down, a slouching into mediocrity. Where is the desire to excel and the search for excellence?

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