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WORKING PAPER SERIES

Improving Education: How Large are the Benefits? How can it be done Efficiently?

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IMPROVING EDUCATION:

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HOW CAN IT BE DONE EFFICIENTLY?

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IMPROVING EDUCATION:
HOW LARGE ARE THE BENEFITS?
HOW CAN IT BE DONE EFFICIENTLY?

"The fate of empires depends on the education of youth"
-Aristotle

If your plan is for one year, plant rice. For ten year plant frees.
For a hundred years, educate women and men.
-Kuan'-tze

The Problem

The National Assessment of Educational Progress (NAEP) reports that 92 percent of high school seniors cannot "integrate specialized scientific information" and do not have "the capacity to apply mathematical operations in a variety of problem settings." (NAEP 1988a p. 51, 1988b p. 42) According to the 1992 National Adult Literacy Survey, only 23 percent of adults are able to reliably determine correct change using information from a menu (National Center for Education Statistics, 1994 Table 1.3).

Secondary school completers in Northern Europe and East Asia are considerably better prepared in mathematics, science and foreign languages than their American counterparts. Figures 1 to 4 plot the scores in Algebra, Biology, Chemistry and Physics during the early 1980s against the proportion of the 18-year old population in the types of courses to which the international test was administered (Postlethwaite and Wiley, 1994). The Americans who participated in the Second International Mathematics Study were high school seniors in college preparatory math courses. This group, which represented only 13 percent of American 17 year olds, was thought roughly comparable to the 15 percent of youth in Finland and the 50 percent of Hungarians who were taking college preparatory mathematics. In Algebra, the score of 40 percent correct for this very select group of American students was about equal to the score of the much larger group of Hungarians and substantially below the Finnish score of 79 percent correct (McKnight et al 1987).

The findings of the Second International Science Study were similar. Take Finland and Canada, for example. The 41 percent of the Finnish students who were taking some biology in their senior year of secondary school got 50 percent correct. The 28 percent of English speaking Canadians taking biology got 43.7 percent correct. The 12 percent of Americans taking a second biology course in senior year got 38 percent correct. The 16 percent of Finns and the 25 percent of English speaking Canadians taking chemistry knew almost as much as the 2 % of American high school seniors who were taking their second year of chemistry (many of whom were in "Advanced Placement") (Postlethwaite and Wiley, 1994).

It is sometimes said that low achievement is the price one must pay for greater access. While the share of all adults with high school diplomas is higher in the U.S. than in other nations, this is no longer the case for young adults. Table 1 presents data on the ratio of secondary school diplomas awarded to population for a variety of industrialized countries. The ratio is over 100 percent in Denmark, Finland and Germany, 90 percent in Japan, 85 percent in France and 65 percent in England. Despite the minimal standards for getting a diploma in the United States, the ratio of secondary school diplomas awarded to population 18 years of age was only 73.7 percent in 1988, slightly below its level in 1968.[1] Standards were lowered in the 1970s, but completion rates did not improve.

Participation in post secondary education is higher in the United States (see Table 1), but most college freshmen are studying material that European university students studied in secondary school. Many Europeans doubt that BAs from second rank American universities are equivalent to the French *Licence* or the Dutch *Doctoraal examen.*

In the economically critical fields of science, mathematics, computer science and engineering, degree production relative to population exceeds U.S. levels in Japan, Norway, France and Ireland. Finland, Canada, Denmark, and Germany produce proportionately just about as many people trained in these fields as the United States. Only Italy, the Netherlands and Sweden are distinctly below the U.S. Many observers believe that the abundance and quality of scientists and engineers has historically been an important source of competitive advantage for American companies. This advantage is diminishing.

I. THE ECONOMIC CONSEQUENCES OF EDUCATION

1.1 The Effect of the Quantity of Schooling on Wages

Educational attainment is the single most important determinant of a person's success in the labor market. According to the most recent Census report, persons over the age of 18 without a high school degree earned only $12,809 on average in 1992, a poverty level standard of living for a family of three. **High school graduates earned 46 percent more than drop-outs** or $18,737 on average**. Associate degrees holders earned 30 percent more than high**

[1] If GED certificates were counted as diplomas, American secondary school graduation rates would be about 10 percentage points higher. The labor market, however, does not view the GED as equivalent to a high school diploma. GED certified high school equivalents are paid 6 percent more than high school dropouts but 8 to 11 percent less than high school graduates. Most GED test takers spend little time preparing for the exam. The median examinee spent 20 hours preparing for the exam and 21 percent did not prepare in any way. Their ASVAB test scores are above those of other high school dropouts but significantly below those of high school graduates. (Cameron and Heckman1993). Hence, the OECD did not think GED certificates should be counted as high school diplomas.

school graduates or $24,398 on average. **Bachelors degree holders earned 31 percent more than those with AA degrees**, or $32,629 on average**. PhDs earned 68 percent more than BAs and those with professional degrees earned 128 percent more than BAs** (Census Nov. 1994). Only a third or so of these wage differentials are caused by pre existing differences in ability, motivation and family background.[2] The lions share of the gains represent the real value added of extra schooling. In the 50 years it has been tracked, the payoff to schooling has never been higher.

Is there a danger of over doing the expansion of higher education? Newspaper stories about laid off managers and professionals led some to mistakenly announce the end of the strong labor market for college graduates. While the 1991-92 recession saw a cut back in the hiring of recent college graduates, young high school graduates suffered even more. Even at the height of the recession unemployment rates of college graduates never exceeded 3.5 percent. Their unemployment rates are now less than 2.5 percent.[3] Those who completed their BA in 1994 were quite successful in getting good jobs.

What about the future, however? Let us begin by looking at projections of the supply of college graduates. The high economic payoffs to college during the late 1980s and 1990s resulted in a big increase in the ratio of BAs awarded to the number of 22 year olds--from 21.6 percent in 1980 to 29.9 percent in 1992. This ratio is projected to increase further to 33.8 percent in the year 2000, a 56 percent increase over 1980 (NCES Jan. 1995). The proportionate increase in the total number of BAs awarded, however, is much smaller because the low birth rates of the 1960s and 70s means that there are significantly fewer individuals in the 20 to 30 year old age cohort that typically receives most of the BAs. **As a result, the ratio of the number of BAs awarded to total employment fell from 1.09 percent in 1974 to 0.95 percent in 1980 and 0.96 percent in 1992. It is projected to fall even further to 0.88 percent in 2000 and 0.86 percent in 2005. Thus, despite the technology driven shift in**

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[2] Corrected estimates of private returns to schooling can be obtained by including measures of ability in the model (Griliches and Mason 1972; Taubman and Wales 1975, Hause 1975) or by using sibling data to match people on ability and socioeconomic factors (Behrman et al. 1977; Olneck 1977). Corrected estimates of rates of return must also take into account downward biases introduced by errors in measuring schooling (Bishop 1974; Griliches 1979) and the probability that those who choose to continue schooling face higher rates of return than those who do not (Willis and Rosen 1979). When models correcting for omitted variables and selection effects were estimated in the 1970s, impacts of years of schooling were typically smaller than in simpler models but the effects were still quite strong. Ashenfelter and Krueger's (1992) recent studies employing comparisons of identical twins which correct for the biasing effects of measurement error in schooling found the effect of schooling to be about as large as the standard cross section relationship.

[3] Unemployment rate of managers and professionals, which was 2.0 percent in the first quarter of 1989, rose to 3.5 percent in September 1992 and have since fallen to 2.2 percent by November 1994. The unemployment rate of operatives and

employer demand in favor of college educated workers, the flow of new graduates into the labor market has declined. To make matters worse the number of college graduates retiring from the labor force is increasing every year (as the veterans who went to college under the GI bill retire from the work force). As a result, the ratio of workers with a college degree to those with a high school degree or less is projected to grow at only 2.9 percent per year between 1988 and 2000, significantly below the 3.5 percent per year growth of this ratio between 1980 and 1988 and the 4.9 percent per year growth between 1972 and 1980 (Bishop 1992).

Now let us examine projections of the demand for college educated workers. In 1991 Shani Carter and I published two papers forecasting a continuation of upskilling trends (Bishop and Carter 1991; Bishop 1992). These papers employed a regression analysis of changes in occupational employment shares during the 1972 to 1991 period to project future occupational employment shares. The variables found to have significant effects on occupational shares were: a simple trend, the unemployment rate, the merchandise trade surplus as a proportion of GDP, and the ratio of personal computers used in business to total employment. The personal computer variable captures the accelerated introduction of computer technology during the 1980s as well as the direct effects of microcomputers. The preferred model containing all four variables predicted that managerial, professional and technical jobs will account for 68 percent of growth of occupational employment between 1990 and 2005. Dropping the variable representing the share of the work force with a PC on their desk lowers the projected high skill share to 57 percent and dropping both the trade deficit and PC share lowers it to 52.5 percent. So far these projections are pretty much on track. **Managerial, professional and technical jobs accounted for 59 percent of the 6,728,000 increase in jobs between November 1989 and November 1994.**[4]

If, as predicted by our models, the relative demand for college educated workers continues to grow at rates similar to those that prevailed in the 1960s, 70s and 80s, current very

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laborers, which was 7.7 percent in the first quarter of 1989, rose to 11.4 percent in July 1992 and has returned to 7.7 percent in November 1994.

[4] The BLS projects that managerial, professional and technical jobs will account for 40.9 percent of job growth to the year 2005 (Silvestri and Lukasiewicz 1991). However, the BLS method of projecting occupational changes has consistently under predicted the growth of managerial and professional jobs. They start with an assumption--the occupational composition of employment in individual industries will not be radically different in the year 2005--that is manifestly wrong. A few ad hoc adjustments are made to the occupational compositions projections for 2005, but most of these parameters are taken as fixed. This results in a substantial understatement of upskilling trends. In 1981 the BLS projected that professional, technical and managerial jobs would account for 28 percent of employment growth between 1978 and 1990. Data from the Current Population Survey indicate that these occupations, in fact, accounted for 53.6 percent of 1978-90 job growth.

high wage premiums for college education will continue and may even escalate further. The latest data (presented in Figures 5a and 5b) support the predictions made 4 years ago of continuing escalation of the wage differential between college graduates and high school graduates. The earnings of male college graduates fell slightly from 1989 to 1993. But the wages of high school graduates fell even more, so the payoff to getting a college degree grew dramatically. For females, there were increases in both the earnings of college graduates and the differential between high school and college graduate. The present discounted value (PDV) at age 21 of the earnings plus fringe benefit gains associated with a college degree are $360,000 of which at least $240,000 represents real value added.[5] A four year college education entails approximately $37,500 in student time costs and $54,500 in instructional costs (OECD 1993 Table P6). Consequently, the social benefits of a college education are at least 2.5 times the social costs.

Clearly increases in the quantity of schooling have high social payoffs. Most of the policy debate, however, is about the quality dimension. How would improvements in student achievement affect the economy? It is to this I now turn.

1.2 The Effect of Education Quality on Wages and Productivity

The mathematical, scientific and technical competencies of workers have big effects on:

* their wages and earnings,
* their productivity on-the-job and
* the nation's standard of living and competitiveness.

Each of these will be taken up in turn.

1.2.1--Consequences for Wages and Earnings

Academic achievement has major effects on the wages of adults even when demographic characteristics and years of schooling are held constant. In the Department of Education's literacy survey, high school graduates who are in the top 5 percent in quantitative literacy earn more than twice as much as high school graduates who are in the bottom 15 percent of the literacy distribution. Holding years of schooling constant, a grade level equivalent increase in quantitative literacy raised 1992 annual earnings by 5.7 percent or about $900

[5] All of the present values calculated in this paper assume that unreported earnings, fringe benefits and employer paid taxes on labor sum to 25 percent of reported earnings, working lifetimes are 45 years on average and a 5 percent real rate of discount (Bishop 1974). Thus the formula for PDV = [earnings differential] *1.25*20*.895. The calculations also assume no growth in the magnitude of the differential being valued. In reality both inflation and productivity growth will cause all wage differentials to grow over time at roughly the rate at which nominal wages grow. This means that our calculations are conservative and comparable to PDV estimates which assumed nominal wage growth of 3 percent per year and which use an interest rate of 8 percent, the current coupon on long term government bonds.

annually (NCES 1995 Table 4.7). The present discounted value (PDV) of the increase in compensation resulting from a one grade level equivalent (GLE) increase in quantitative literacy is about $20,100 (see Table 2).

Analysis of a higher wage group, household heads in the Panel Study of Income Dynamics, found that increases in general academic achievement raised earnings by about 4 percent or $1400 annually per GLE (Bishop 1989). The PDV of the increase in compensation resulting from the one GLE achievement gain was about $31,300 in 1993 dollars.

A third study has examined the effect of different types of academic and technical competencies on hourly wage rates and annual earnings of young people in 1981, 1982, 1983, 1986, 1989 and 1991 (Bishop 1994). The effects of a one population standard deviation [approximately 5 Grade Level Equivalents (GLE)] increase in various kinds of achievement are presented in Figures 6a, 6b, 6c, and 6d. At the time of the 1991 interview this sample of NLS Youth ranged from 26 to 33 years of age.

For young women, speed in arithmetic computation and mathematical reasoning ability both had substantial effects on wage rates and earnings. A one GLE increase in both raised wage rates by 2.3 and 2.8 percent in 1986 and 1990 respectively and earnings by 4.8 and 5.2 percent respectively. Verbal competence had somewhat more modest positive effects on wages (+.5 percent per GLE) and earnings (+ 1.5 percent per GLE). Knowledge of technology and science had no significant effect on wage rates or earnings. A one GLE increase in all competencies raised annual earnings by $715 in 1990.

For young men, technical competence, math reasoning ability and speed in arithmetic computation raised wage rates and earnings, but verbal and scientific competence did not. A one GLE increase in all competencies increased earnings by $956 in 1990. Table 2 summarizes a variety of estimates of PDV in 1992-93 dollars of the compensation increase that the models predict will result from a one GLE increase in all types of competence holding years of schooling constant. Row 4 presents PDV estimates for 1990 data when the sample was 25 to 32 years old. The PDV of a one GLE improvement in test scores is $18,200 for women and $23,500 for men. These estimates are lower bound estimates of the total effects of a one GLE increase in academic achievement. Nevertheless, they are many times larger than the instructional costs for one year of elementary and secondary schooling--$5,566.

Rewards for academic achievement are small at first but grow with age. Academic achievement improves access to jobs offering training and enables workers to get more out of the training. Furthermore, academic achievement is poorly signaled to employers so there are long delays before the labor market identifies and rewards workers who because of their academic achievements are exceptionally productive workers. Measures of non-cognitive achievement in high school such as rates of attendance, extracurricular activities and an absence of discipline problems also fail to have positive effects on initial success in the labor market for the non-college bound in High School and Beyond data (Hotchkiss 1985, Bishop, Blakemore and Low 1985, Rosenbaum 1989).

An important implication of this analysis is that **mathematical and technical skills of average workers generate much greater wage and productivity benefits than verbal and scientific skills.** Analysis of 1984-85 annual earnings using NLSY data found that a one PopSD increase in both computational speed and mathematical reasoning ability raised annual earnings of young women (men) by $1174 ($1097), some of it coming from a higher probability of being employed. The effect of a one PopSD increase in verbal (science) achievement on annual earnings was only $147 (-$91) for young women and -$150 (-$124) for young men. A one PopSD increase in technological knowledge increased earnings of young men by $1343 (Bishop 1993).

1.2.2--Consequences for Productivity on the Job

Direct estimates of the relative importance of different competencies can be obtained by estimating models in which measures of job performance in military and civilian jobs are regressed on scores on a variety of tests assessing academic and technical competencies. Figures 7 and 8 present the results of two studies of the training success and job performance of Marine recruits (Sims and Hyatt 1981, Maier and Grafton 1981). The darker bars provide estimates of the effect of a one population standard deviation improvement in each of the ASVAB subtest composites on the hands-on job performance, while holding all other test scores constant. The lighter bars provide similar estimates from models predicting paper and pencil measures of job knowledge at the completion of training. In non-clerical jobs in the military a one PopSD increase in a technical skills raised productivity 11.9 percent and a similar increase in mathematics reasoning skills raised productivity by 5.3 percent. The other skills had much smaller effects on productivity. In clerical jobs in the military, a one PopSD increase in math reasoning ability raised productivity by 10.8 percent and a similar increase in verbal skills raised productivity by 3.5 percent (Bishop 1994).

Studies of job performance in civilian jobs get similar results. Competence in mathematics has major effects on supervisory ratings of performance in all jobs. Technical competence has big effects in blue collar and technical jobs. Verbal ability has no effect on performance in blue collar jobs, but in clerical, technical and service jobs, it makes important contributions to productivity (Bishop 1994).

Not only does competence in mathematics help you get high paying jobs, it makes you more productive in specific jobs, even in clerical jobs such as typist which casual observation suggests require verbal skins not mathematics skills. Why? I think the reason math (including algebra) has such a pervasive effect on worker productivity is the logic and problem solving skills that people learn in mathematics courses. These skills help clerical workers learn word processing and other computer programs and helps them solve other everyday problems at work.

The PDVs for general improvements in academic and technical achievement range from $14,200 for women in clerical jobs to $31,900 for males in non-clerical jobs in the military. Because they hold the job fixed, these estimates measure only a portion of the total direct productivity benefits of improvements in academic and technical achievement. Nevertheless, these downward biased estimates are many times larger than the costs of one year of instruction. Consequently, even rather expensive reforms of schooling that increase learning--such as longer school days and longer school years--probably have benefit cost ratios that substantially exceed 1.

1.2.3 Consequences for Economic Growth

Improvements in educational achievement were important contributors to productivity growth during the first three-quarters of the twentieth century (Jorgenson, Gollop and Fraumeni 1987, Denison 1988). Did the contribution of education to productivity growth diminish after 1973? Were problems in the education sector contributors to the productivity growth slowdown and the resulting declines in competitiveness and real wages? The answer is yes.

The 1.25 grade level equivalent decline in the test scores of American secondary school graduates between 1967 and 1980 signaled a significant deterioration in the quality of young entrants into the American work force. This decline was unprecedented, for prior to 1967 student test scores had been rising steadily for more than 50 years. In a paper published in The American Economic Review in 1989, 1 calculated that improvements in general academic achievement (GAA) holding years of schooling constant contributed an additional .212 percent per year to the growth of the quality of labor from 1948 to 1973. Gains in GAA holding schooling constant, thus, increased labor quality by 5.4 percent over the course of the full 25 year period. Jorgenson, Gollop and Fraumeni (1987) estimate that increases in years of schooling caused labor quality to grow .725 percent per year or a total of 19.9 percent over the course of the 25 years. In combination, the gains in years of schooling and in GAA holding schooling constant increased labor quality 26.3 percent by the end of the period.

After 1973, however, gains in years of schooling and the GAA of those completing specified amounts of schooling began to decelerate. Between 1973 and 1979, the contribution of years of schooling to the growth of labor quality diminished to .612 percent per year. The contribution of schooling-constant GAA gains to the growth of labor quality fell to .157 percent per year between 1973 and 1980 and fell even further to .084 percent per year between 1980 and 1987. If the test scores of high school graduates had continued to grow at the rate that prevailed between 1942 and 1967, labor quality would have been 3.6 percent higher in 1990. The annual social cost in terms of foregone GNP was more than $120 billion in 1990. Even with a forecast of rapid improvements in the quality of elementary and secondary education in the 1990s, the labor quality shortfall grows to 5.5 percent in 2000 and 6.7 percent in 2010.[6]

While the education enterprise has historically been an important source of economic growth, education reform is not a silver bullet that can cure our overall productivity growth problem. A reform of elementary and secondary education that increased the competence of all school leavers by one grade level equivalent (without increasing years spent in school) would be considered a big success. Yet, since the annual flow of young school completers into the labor market is only 3 percent of total employment, such a reform would increase productivity growth by only 0.20 percent per year?[7] It would take 5 years for this reform to increase productivity by just 1 percent. Thus, successful reform of K-12 education is not likely to dramatically improve productivity in the short and medium term. Similarly, the education problems that developed in the late 1960s and 1970s were not the primary cause of the subsequent slowdown of productivity growth. Variations in productivity growth rates over time have many causes, of which education is only one.

This does not imply, however, that the productivity consequences of educational achievement are of little import. **Rather it implies that they take a long time to develop.** Our hypothetical reform raises productivity growth for roughly 40 years and the 6.7 percent increase

[6] The only way to prevent these forecasts from being realized is to change the relationship between GAA at age 17 and GAA as an adult. This might be accomplished by attracting massive numbers of adults back into school, by expanding educational offerings on television and/or by inducing employers to provide general education to long term employees.

[7] I make the conservative assumption that controlling for preexisting ability differences reduces the impact of a year of secondary school on earnings from the 16 to 20 percent found in raw census data to 10 percent. This 10 percent figure is multiplied by 2/3rds, labor compensations' share of total output, to get the long run effect of the reform on GDP. The annual figure is obtained by multiplying .067 by .03, the ratio of the flow of school leavers to the total labor force. Slow productivity growth is also often blamed on insufficient saving and investment, yet a $120,000,000,000 (2 percent of GDP) increase in the savings rate would increase the growth of Net National Product by only about 0.1 percent per year (Denison 1986). In other words, aggregate productivity levels are not very sensitive to any kinds of policy intervention whether it be investment in physical or human capital.

in annual output that eventually results is permanent. The nation spends only 4.5 percent of GDP on elementary and secondary education. If a reform of that sector can yield a benefit that on an annual basis is 50 percent greater than total annual spending on K-12 education, the case for that reform would appear to be very strong, even if it takes decades for the reform to have its full effect. If such a reform were implemented now, the present discounted value (using a 5 percent real discount rate) of the projected increase in GDP would be roughly 3.4 trillion dollars.[8] **Education has effects which last a lifetime, indeed generally for many lifetimes** (Haveman and Wolfe 1984).

II. EFFICIENT WAYS OF IMPROVING ACHIEVEMENT

One of the unique characteristics of the American education system is that all the really important decisions--budget allocations, hiring selections, salary levels, teaching strategies, grading standards, course offerings, pupil assignments to courses and programs, disciplinary policies, etc.--are made by classroom teachers and school administrators who are responding to local political pressures. Federal and state officials are far removed from the classroom, and the instruments available to them for inducing improvements in quality and standards are limited. They do not have effective control of the standards and expectations that prevail in the classroom. They do not control the allocation of school funds between academics and athletics.

Aid from higher levels of government can be increased; but econometric studies suggest that increases in state aid reduce local property tax collections by a significant amount (Carroll 1982; Ehrenberg and Chaykowski 1988). For every extra dollar of noncategorical state aid to local school districts only about 50 cents is spent on education by the locality: the rest either lowers tax rates or enables the community to spend more on other public functions. For categorical programs like Title 1, the increase in local education spending is larger, but some leakage appears to be inevitable (Tsang and Levin 1983; Monk 1990). The role of the federal government is inevitably very limited. Most of the key decisions are made by students and parents.

2.1 What Must Be Done

Educational researchers and policy makers have proposed a host of changes in educational practice and parent behavior designed to increase academic achievement. A sampling follows:

[8] We assume that it takes 40 years to replace the entire work force at a rate of .025 per year. The formula for calculating the present discounted value of an educational reform which raises the productivity of all school leavers by 10 percent is .10(2/3)($6.0 trillion)(.025)(1/r)(1/r)(1-e~') = $3.4 trillion.

- Teachers must assign more homework and the assignments must be completed. Yet in some schools "Students were given class time to read The Scarlet Letter, The Red Badge of Courage, Huckleberry Finn, and The Great Gatsby because many would not read the books if they were assigned as homework. Parents had complained that such homework was excessive (Powell, Farrar and Cohen 1985, p.81)."
- Parents must tell children: "Turn off the TV and do your homework." Currently, American students spend 19.6 hrs/wk watching TV while students spend only 6.3 hrs/wk in Austria, 9.0 hrs/wk in Finland, 5.9 hrs/wk in Norway and 10.9 hrs/wk in Canada (OECD 1986).
- Students must be engaged in learning--Yet, Frederick, Walberg and Rasher (1979) estimated 46.5 percent of potential learning time was lost due to absence, lateness, and inattention. After hundreds of hours of classroom observation, Theodore Sizer (1984) described students as, 'As *all too often docile, compliant and without initiative (p. 54). "*
- Students must choose rigorous math and science courses. Yet of those graduating in 1982, only 31 percent had taken chemistry, only 14 percent had taken physics. Only 46 percent had taken geometry and only 35 percent had taken Algebra 11 (NCES 1993 pp. 68, 72). In Canada 25 percent of all 18 year olds are studying science at a level of difficulty that is comparable to AP level courses taken by only about 3 percent of U.S. students (Posthlewaite and Wiley 1992).
- School Boards must be willing to raise local taxes so they can offer better salaries to attract better teachers to their community. Relative to other workers, experienced American upper secondary teachers are currently paid less than 80 percent of what their counterparts in Canada, Finland, France, Germany, Japan, the Netherlands, Norway and the United Kingdom earn(Nelson and O'Brien 1993, pp. 73-74, 9091).
- Parents must demand higher standards at their local school. Yet despite the fact that their 5th graders were far behind their Taiwanese and Japanese counterparts in mathematics, 91% of American mothers rated their local school "good" or "excellent." Only 42 percent of Taiwanese and 39 percent of Japanese parents were equally positive (Stevenson, Lee and Stigler 1986).

What almost all of these proposed explanations of educational deficits have in common is that key actors in the learning enterprise (students, parents, teachers, administrators and/or school boards) are being accused of giving insufficient priority to the goal of academic achievement. Some other goal--eg. leisure, avoiding controversy, low taxes, equity--is taking precedence over the academic achievement of students.

Regardless of which of the proposed causes of poor academic performance are the most important, a more fundamental question remains: "Why do American students, parents, teachers, administrators and school boards apparently place a lower priority on the goal of academic achievement than their counterparts in Europe and East Asia." My answer to this question is:

> ***The fundamental cause of the low effort level of American students, parents, and voters in school elections is the absence of good signals of effort and learning in high school and a consequent lack of rewards for effort and learning ... In most other advanced countries mastery of the curriculum taught in high school is assessed by ... examinations which are set ... at the national or regional level. Grades on these exams signal the student's achievement to colleges and employers and influence the jobs that graduates get and the universities and programs to which they are admitted. How well the graduating seniors do on these exams influences the reputation of the school and in some countries the number of students applying for admission to the school. In the United States, by contrast, students take aptitude tests that are not intended to assess the learning that has occurred in most of the classes taken in high school. 77je primary signals of academic achievement are grades and rank in class--criteria which assess achievement relative to other students in the school or classroom, not relative to an external standard*** **(Bishop 1990b).**

2.2--Curriculum Based External Examinations

STUDENT AND PARENT INCENTIVES: External assessments of achievement in specific high school subjects increase rewards for learning and this should induce the student to choose tougher courses and work harder in them. When such exams are absent, many students choose courses that have the reputation of being fun and not requiring much work to get a good grade. As one student who had avoided the harder courses even though she was sure she could do the work explained her decision: *"Why should I do it,* [the extra work] if *I don't have to?"* (Ward 1994) Teachers know this and adjust their style of teaching and their homework assignments with an eye to maintaining enrollment levels:

> *An angry math teacher [who remembering] the elimination of a carefully planned program in technical mathematics for vocational students simply because not enough signed up for it,...[said] 'Its easy to see who really makes decisions about what schools teach: the kids do.'* (Powell, Farrar and Cohen 1985, p. 9)

External assessments also have pervasive effects on the **structure** of student rewards. When signals of achievement assess performance relative to fellow students (eg. grades and class rank) rather than relative to an absolute standard, students have a personal interest in persuading each other not to study. The studious are called nerds, in part, because they are making it more difficult for others to get good grades. Since devoting time to studying for an exam is costly, the welfare of the entire class is maximized if no one studies for exams which are graded on a strict curve. The cooperative solution is "no one studies more than the minimum." Participants are generally able to tell who has broken the "minimize studying" code and reward those who conform and punish those who do not. Side payments and punishments are made in a currency of friendship, respect and ridicule that is not limited in supply. For most students the benefits that might result from studying for the exam are less important than the very certain costs of being considered a "brain geek", "grade grubber" or "acting White," so most students abide by the "minimize studying" "don't raise your hand too much" norm. Most American students are part of friendship circles in which the following norms prevail: *It is OK to be smart. You cannot help that. But, it is definitely not OK to spend a lot of time studying. Instead, use your free time to socialize, participate in athletics or earn money.* When learning is assessed relative to an outside standard, students no longer have a personal interest in getting the teacher off track or persuading each other to refrain from studying.

ADMINISTRATOR INCENTIVES: Some American school administrators focus on lowering the failure rate rather than raising achievement and end up pressuring their teachers to lower standards. A principal who had recently fired a teacher for failing too many of her students justified his decision with the following:

> *I have made it very clear that one of my goals is to decrease the failure rate, to make sure the kids feel good about learning, stay in class, stay in school and do well... Math is just a big body of knowledge, what is Algebra H across the nation anyway?" he asks. When he taught band, he adds, he certainly didn't expect kids to finish the year as musicians--but he did want them to know more about music than they did before ... All the talk about preparing students for college struck him as "ludicrous." Instead the goal should be to keep students studying math (Bradley, Sept 19, 1993 p. 19, 20).*

When there is no external assessment of academic achievement, students and their parents benefit little from administrative decisions that opt for higher standards, more qualified teachers or a heavier student work load. The immediate consequences of such decisions--higher taxes, more homework, having to repeat courses, lower GPA's, complaining parents, a greater risk of being denied a diploma--are all negative. Since college admission decisions have historically been based on rank in class, GPA and aptitude tests, not externally assessed achievement in high school courses, upgraded standards will not improve the college admission prospects of next year's graduates. Graduates will probably do better in difficult college courses and will be more likely to get a degree, but that benefit is uncertain and far in the future. Maybe over time the school's reputation and, with it, the admission prospects of graduates will improve because the current graduates are more successful in local colleges. That, however, is even more uncertain and postponed.

The Scholastic Aptitude Test is no substitute for curriculum based exams because it does not assess knowledge and understanding of science, history, social science, statistics and calculus or the ability to write (Jencks and Crouse 1982). Consequently, parents can see that improving the teaching of these subjects win have only minor effects on how their children do on the SAT, so why worry about standards? In any case, doing well on the SAT matters only for those who aspire to attend a selective college. Most American students plan to attend public colleges which admit all high school graduates from the state with the requisite courses.

External exams in high school subjects can be expected to transform the signaling environment. There is now a very visible payoff to hiring better teachers and improving the school's science laboratories. Larger numbers of students pass the external exams and this in turn influences college admissions decisions. School reputations will now tend to reflect student academic performance rather than the family background of the community or the success of football and basketball teams. If additionally parents and students can choose which high school to attend and aid from higher levels of government is based on enrollment, the stakes for the school administrators become very high indeed. Poor student performance on the external exams might force layoffs of school staff.

2.2--Evidence of the Effects of Curriculum Based Exams on Learning

Probably the best evidence on the impact of curriculum based exams comes from comparing jurisdictions with such examinations to those without. The jurisdictions should be reasonably large, because otherwise colleges and employers are not likely to use grades on the curriculum-based exams in their selection decisions, so the rewards for doing well may be quite limited.

New York vs the Rest of the United States: New York State is reasonably large and has a Regents Examination system which reaches over half of the state's high school students?[9] It is, indeed, the only state in the U.S. with a curriculum based examination system

[9] About 56 percent of 9th graders take the Mathematics Course I exam and, of these, 24 percent fail. Similar proportions of 10th and 11th graders take the global studies, biology and English exams. Failure rates were 20 percent in global studies, 18 percent in biology and 13 percent in English. The great bulk of those not taking Regents exams are in courses that are considerably less challenging than Regents level courses. The fact that nearly half of New York students are avoiding Regents courses because they perceive them to be too much work or too difficult suggests that the standard of the exam is about as high as is feasible considering current average achievement levels in the state.

covering the majority of high school graduates.[10] California is currently trying to introduce one. Consistent with the theory laid out above, the Regents exams (or something else unique to New York State) has raised statewide achievement levels. When the family income, parental education, race and gender of SAT test takers are controlled, New York State has the highest adjusted mean Scholastic Aptitude Test score of the sample of 38 states with adequate numbers of test takers to be included in the study (Graham and Husted, 1993).[11] This occurs despite that fact that Regents exam grades account for less than half of the course grade and influence only the type of diploma received. A passing score on Regents exams is not necessary for admission to non-university higher education and employers ignore exams results when they make hiring decisions.

Comparing Canadian Provinces: Probably the best place to test hypotheses about the impact of curriculum-based external examinations is Canada. Some Canadian provinces--Quebec, Newfoundland, Alberta, New Brunswick and British Columbia--have curriculum-based exams; the others do not (U.S. GAO 1993). The hypotheses outlined in section 2.1 were tested in data on the mathematics and science competence of 42,241 Canadian and American 13 year olds from the International Assessment of Educational Progress (LAEP). Holding the social class background of students constant, students from Canadian provinces with examination systems were substantially (23 percent of a standard deviation) better prepared in mathematics and 18 percent of a standard deviation better prepared in science than students from provinces lacking such exams. The effect of an exam system on mathematics achievement of 13 year olds was larger in a standard deviation metric than the decline in math SAT scores between 1969 and 1980 that has been such a focus of public concern.

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[10] The Advanced Placement (AP) examinations are an exception to the generalization that the U.S. lacks a national system of curriculum-based examinations. Students who take these courses and pass the examinations may receive college credit for high school work. While it is growing rapidly, AP is still a very small program. In 1988 only 8,022 of the 22,902 U.S. high schools offered any AP courses. Only 52 AP exams were taken on average in each participating high school (The College Board 1988). Of the 11th and 12th graders in 1993, only 2.8 percent took an AP English exam, 2.3 percent took an AP history exam, 1.7 percent took the AP calculus exam, and 1.7 percent took an AP science exam (NCES 1993). AP students learn more not just because they are a self selected group of highly able students but because the external examination aligns incentives in a way that induces both teachers and students to give higher priority to learning.

[11] Dynarski and Gleason (1993) have also predicted state mean SAT scores while controlling school resource variables and characteristics of the state's population obtained from the Census. Graham and Husted's analysis is preferable for our purposes because it uses data on the background of the students who took the test and no effort was made to control school resource variables that might be influenced by the existence of Regents exams.

The analysis also found that examination systems had pervasive effects on school administrators, teachers and parents. In the provinces with external exams, schools were more likely to:

--employ specialist teachers of mathematics and science
--employ teachers who had studied the subject in college,
--have high quality science laboratories
--Schedule extra hours of math and science instruction
--assign more homework in math, in science and in other subjects
--have students do or watch experiments in science class and
--Schedule frequent tests in math and science class.

At home students watch less TV, spend more time reading for fun, and are more likely to report their parents want them to do well in math and science. In addition, parents are more likely to talk to their child about what they are learning at school. None of the undesirable effects that opponents of external exams have predicted came about.

Other natural experiments yield similar findings. Sweden eliminated its system of high/medium stakes examinations in the early 1970s. It is clear in Figures 9 and 10 that in the decade that followed, the performance of Swedish secondary school seniors on international assessments of achievement in mathematics and science deteriorated relative to other nations (Bishop 1984b).

III. A STRATEGY FOR IMPROVING SECONDARY EDUCATION

It is easy to list ways of increasing educational achievement: greater attention in class, more reading, less TV, more homework, more challenging courses, better school climates, better teaching, more competent teachers and longer school years. There are, however, no magic bullets. Young people in other nations learn more than our youth because they work harder at it. What is difficult is identifying practical ways of inducing 47,000,000 students to study harder and 80,000,000 parents to demand higher quality, higher standards education for their children. There are 22,731 public secondary schools in the United Sates that are run by 15,358 largely autonomous local education agencies.

This section of the paper outlines a strategy of change built around increasing the rewards at both the individual and community levels for improvements in academic achievement. The key to motivating students to learn and parents to demand a quality education is recognizing and rewarding learning effort and achievement. Some students are attracted to serious study of a subject by an intrinsic fascination with the subject. They must pay, however, a heavy price in the scorn of their peers and lost free time. Society offers them little reward for their effort. Most students are not motivated to study by a love of the subject.

Sixty-two percent of 10th graders agree with the statement, "I don't like to do any more school work than I have to" (Longitudinal Survey of American Youth or LSAY, Q. AA37N). As a result, far too few high school students put serious time and energy into learning and society suffers.

If this situation is to be turned around, the peer pressure against studying needs to be reduced and rewards for learning need to be increased. The full diversity of types and levels of accomplishment need to be signaled so that everyone--no matter how advanced or far behind--faces a reward for greater time and energy devoted to learning. Learning accomplishments need to be described on an absolute scale so that improvements in the quality and rigor of the teaching and greater effort by all students in a school make everybody better off. Colleges need to be induced to select students on the basis of externally validated achievements, not by "aptitude" test scores or rank in class.

If employers know about the academic achievements of job applicants, they can be counted on to provide the rewards needed to motivate study. Ninety-two percent of 10th graders say they "often think about what type of job I will be doing after I finish school" (LSAY, Q. AA13C). If the labor market rewards learning in school, high school students will respond by studying harder and local voters will, be more willing to pay the taxes necessary to have better local schools. The Commission on Workforce Quality and Labor Market Efficiency advocated such a change in 1989:

> The business community should ... show through their hiring and promotion decisions that academic achievements will be rewarded (1989, p. 9).
>
> High-school students who excel in science and mathematics should be rewarded with business internships or grants for further study (1989, p. 11).

Some might react to this strategy for achieving excellence by stating a preference for intrinsic over extrinsic motivation of learning. This, however, is a false dichotomy. Nowhere else are people expected to devote thousands of hours to a difficult task while receiving only intrinsic rewards. Public recognition of achievement and the symbolic and material rewards received by achievers are important generators of intrinsic motivation. They are, in fact, one of the central ways a culture symbolically transmits and promotes its values.[12]

[12] Another possible argument against policies designed to induce employers to reward high school students who study is that poor students will not be considered if an employer learns of this fact. What those who make this argument do not realize is that the policy of providing no information to employers about performance in high school results in no recent graduates (whether good or poor student) getting a job that pays well and offers opportunities for training and promotions. In effect it is being proposed that the interests of the students who do not study and are discipline problems should take precedence over the interests of the students who lived by the schools rules and studied hard. There is nothing unfair about letting high school GPA's influence the allocation of young people to the best jobs. The GPA's are an average which reflects performance on 100's of tests, and the evaluations of over 20 teachers each of which is based on over 180 days of interaction. Selection decisions must be

HOW CAN WE BE SURE THIS STRATEGY WILL WORK? WE KNOW IT WORKS BECAUSE IT HAS ALREADY WORKED.

WE HAVE BEEN FOLLOWING THIS STRATEGY FOR MORE THAN A DECADE. Market responses to technological change have raised the extrinsic rewards for studying in high school. During the 1970s employers typically ignored academic achievement when hiring front line workers. They now pay more attention to the academic qualifications and, as a result, the labor market reward for mathematical ability has risen dramatically (Murnane, Willett and Levy 1994). The payoffs to getting associates degrees and bachelors degrees have nearly doubled.

The education sector has also acted to strengthen rewards for study. Selective colleges have increasingly based admissions decisions on the rigor of the courses that students took in high school. They have reduced their reliance on the SAT and increasingly are discounting high grades obtained in easy courses. States have established minimum competency tests for graduation and increased the number of mathematics and science courses students need to graduate.

The increase in rewards for achievement has caused a rise in standards and in student study effort. Homework assigned and completed has increased. The percentage of 13 year olds reporting they either had no homework or did not do it fell from 33 percent in 1982 to 9 percent in 1990. The percentage of 17 year olds reporting they did at least one hour of homework each day rose from 32.5 percent in 1978 to 66 percent in 1990 (NCES 1993 p. 122, 351). High school graduation rates are creeping up. Students are taking more rigorous courses. Between 1982 and 1990 enrollment shares rose 20 percentage points for Geometry, 14 points for Algebra 11, 19 points for Chemistry and 8 points for Physics (NCES 1993 p. 68). The number of students taking AP exams has tripled.

Higher standards and greater student effort have in turn resulted in higher achievement. **NAEP MATHEMATICS AND SCIENCE SCORES AT AGE 17 HAVE RISEN MORE THAN A GRADE LEVEL EQUIVALENT.** Table 3 and Figure 11 present the evidence. Between 1982

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made somehow. If measures of performance in school are not available, the hiring selection will be determined by the chemistry of a job interview and idiosyncratic recommendations of a single previous employer. Since many employers will not request the information, providing information on student performance does not prevent the poorer student from getting a job; it only influences the quality of the job that the student is able to get.

and 1992, mathematics scores of 17 year olds rose 1.06 GLEs (9 points) and science scores rose 1.22 GLEs (11 points). Reading scores have risen .53 GLEs since 1980.[13]

The declines in achievement during the 1970s have been just about erased. This has been accomplished in the face of growing numbers of students from minority and disadvantaged backgrounds. Between 1977 and 1990, the black and Hispanic share of NAEP test takers rose from 16 to 23 percent. Their achievement levels improved by roughly 2 grade level equivalents between 1980-82 and 1992. While the absolute levels of achievement remain disappointing, substantial progress has been made and rising NAEP scores for younger students suggests that the achievement of high school graduates will probably continue to improve.

The 1+ grade level equivalent gain in mathematics and science achievement is nothing to sneer at. Because of it, each high school graduates during the 1990s can expect to earn an additional $1000+ per year for the rest of their life. That is the implication of the numbers presented in Table 2. If the gains in math and science were replicated in all other subjects and in the non-cognitive competencies such as dependability and cooperation that normally attend one additional year of schooling, new-entrants into the labor force would now be 10 percent more productive than those who entered at the beginning of the 1980s (the example discussed at the end of section 1.2.3). **The increase in GDP that would result has a present discounted value of 3.4 trillion dollars.**

My conclusion is that education reform is generally headed in the right direction. We appear to be moving ever so cautiously down a path that leads to curriculum based examination systems in many states and school districts. There is no need for a single national system of curriculum based exams. Since curriculum objectives will differ from state to state, states will need to choose the examination/assessment system that fits their goals. States can either develop their own or adopt examinations developed by national organizations such as the College Board, ACT or the National Council of Teachers of Mathematics. The first step is coming to some agreement about what we want students to learn in each subject and how to assess it. This will be difficult, but, if the choices are made at the state rather than the national level, I think agreements can be forged in most states for most subjects.

If it is to survive in the U.S. political environment, the assessments must hand out good news most of the time. Their voluntary character will tend to assure that because

[13] Grade level equivalents on the NAEP IRT scale sores can be calculated by dividing the difference between the scores of 17 year old students and 13 year old students by four. Using this simple approach we can see that a GLE is 8.5 points on the NAEP mathematics scale, 9 points on the NAEP science scale and 7.5 points on the NAEP reading scale (Muffis, et al. 1994).

students and districts that anticipate failing will not volunteer to be assessed. As with the AP exams and European exams, multiple levels of achievement will have to be signaled. There must be honor in simply undertaking the challenge and substantial rewards for those who do well. The system will have to start small and grow the way the Bac did in France and the AP exams have in the United States. Consequently, it will probably be decades before subject based examination systems are widespread in the United States.

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Table 1: Graduation Rates for Secondary and Postsecondary Education

	Sec.Dipl /Pop18	Bachelors /Pop22	Sci,Eng,Math Deg/Pop25 34		Sec.Dipl /Pop18	Bachelor /Pop22	Sci,Eng,Math Deg/Pop25 34
Australia	---	24.4%	8.2%	Italy	76%	9.2%	2.6%
Canada	73%	33.3%	6.2%	Japan	91%	23.7%	9.7%
Denmark	100%	16.5%	6.7%	Netherlands	82%	8.3%	2.5%
Finland	125%	17.2%	7.0%	Norway	89%	30.8%	7.9%
France	76%	16.3%	7.2%	Sweden	80%	12.0%	4.0%
Germany	117%	13.3%	6.8%	United Kingdom	74%	18.4%	7.7%
Ireland	51%	16.0%	8.8%	United States	74%	29.6%	6.5%

Source: OECD, Education at a Glance, 1993, p. 176, 179 & 185. Column 1 is the ratio of secondary school diplomas and credentials awarded in 1991 to population 18 years of age. It exceeds 100 percent in Denmark, Finland and Germany because older individuals from larger birth cohorts are completing their secondary schooling and because some individuals obtain two secondary level credentials (eg. In Germany some recipients of the Abitur pursue 3 year apprenticeships which yield vocational qualifications). The third column is 10 multiplied times the ratio of science, mathematics, computer science and engineering degrees awarded in 1991 at all levels (BS, MS and PhD) to the labor force 25 to 34.

TABLE 2: Alternative Estimates of the Present Discounted Value of Earnings and Productivity Effects of 1 Grade Level Equivalent of General Academic Achievement (Holding Years of Schooling Fixed)

	Female/	Male	
	Clerical	Tech Abil not Incl.	Tech. Abil Included
Weekly Earnings of Adult Household Heads (Panel Study of Income Dynamics--Bishop 1989)	---	$32,000	--
Annual Earnings of the Employed (NCES Literacy Survey 1994)	$20,100	$20,100	--
Earnings of Youth--17-26 yr olds in 1981-85 (Nat. Long. Survey of Youth--Bishop 1994 Chap 5)	$6,900	$2,900	$10,600
Earnings of Young Adults--25-32 yr olds--(1990 NLS-Y--Bishop 1994 Chap 5)	$18,200	$13,400	$23,500
Skill Qualification Tests in Military Holding Job Fixed (Maier & Grafton--Bishop 1994 Chap. 7)	$22,400	$16,100	$31,900
Performance Ratings in Civilian Jobs-Job fixed (General Aptitude Test Battery--Bishop 1994 Chap 8)	$14,200	$15,600	--

Estimates of the present discounted value (PDV) at age 18 (using a 5 percent real discount rate and a 45 year working life) of the compensation and productivity effects in 1992-93 dollars of a one grade level equivalent (GLE) increase in general academic achievement (GAA) while holding years of schooling constant. By comparison the instructional cost of one year of school was $5566 in 1992-93. PDV is calculated assuming that the earnings/productivity differential is the same in every year of the individual's working life. Compensation (including employer paid taxes on labor) is assumed to be 25 percent greater than earnings. A grade level equivalent is defined as equal to 1/5th of a PopSD. General academic achievement includes computational speed, mathematical reasoning, verbal ability and science knowledge. Results for a broader definition of GAA that also includes mechanical comprehension and technical knowledge is presented in column 3. Spatial ability, perceptual ability, clerical speed and psychomotor skills were not considered part of GAA and their effects were controlled for in the GATB analysis. All models reported here included controls for years of schooling. Only the PSID analysis corrected for errors in measuring GAA, so estimates presented in rows 2 to 6 are lower bounds of true effects. The results presented in row 3 and 4 are from earnings regressions and reflect in part higher probabilities of employment and the on-the-job training received since leaving school (Bishop 1994). Earnings effects of GAA grow with age, so estimates of lifetime effects are larger when based on 25 to 33 year olds (see row 4). The results presented in row 5 and 6 are from within job regressions estimated in data on non-professional and non-managerial occupations. Since job is held fixed, they underestimate the total effect of GAA. The dollar estimates of productivity effects in military jobs was constructed by assuming that average productivity of soldiers in clerical jobs was the same as the compensation of civilian workers in comparable jobs.

Table 3: AVERAGE U.S. ACHIEVEMENT TEST SCORES IN SCIENCE, MATHEMATICS, AND READING

Year	NAEP Score: Age 9 – Science	NAEP Score: Age 9 – Mathematics	NAEP Score: Age 9 – Reading	NAEP Score: Age 13 – Science	NAEP Score: Age 13 – Mathematics	NAEP Score: Age 13 – Reading	NAEP Score: Age 17 – Science	NAEP Score: Age 17 – Mathematics	NAEP Score: Age 17 – Reading
1970	225			255			305		
1971			208			255			285
1973	220	219		250	266		296	304	
1975			210			256			286
1977	220			247			290		
1978		219			264			300	
1980			215			258			286
1982	221	219		250	269		283	298	
1984			211			257			289
1986	224	222		251	269		288	302	
1998			212			258			290
1990	229	230	209	255	270	257	290	305	290
1992	231	230	210	258	273	260	294	307	290

SOURCE: Mullis et al. (1994) and the National Assessment of Educational Progress (NAEP)

FIGURE 1 – 4

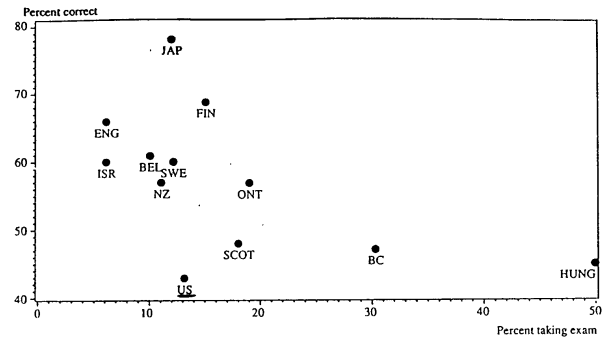


Fig. 1. Algebra results for 17-year-olds

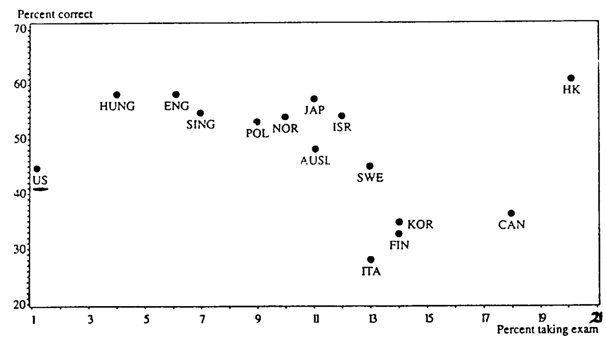


Fig. 2. Physics results for 18-year-olds

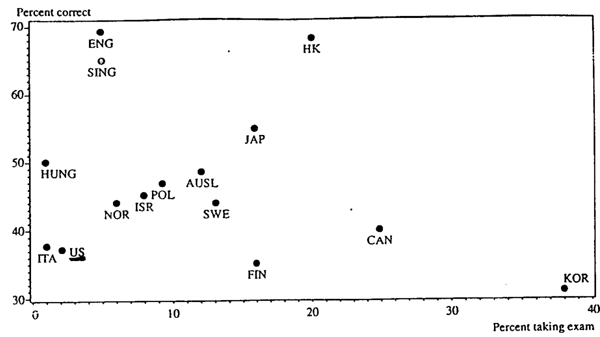


Fig. 3. Chemistry results for 18-year-olds

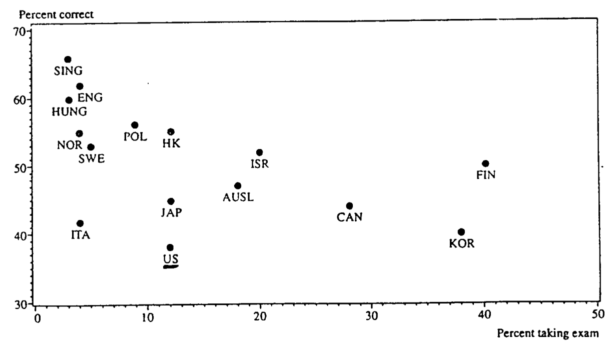


Fig. 4. Biology results for 18-year-olds

FIGURE 5a

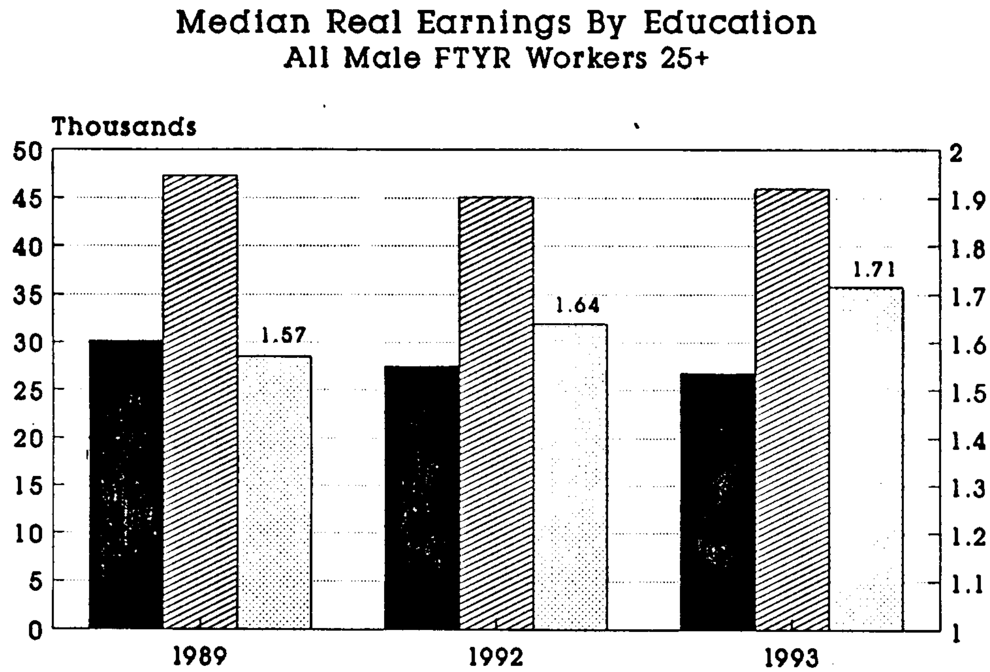
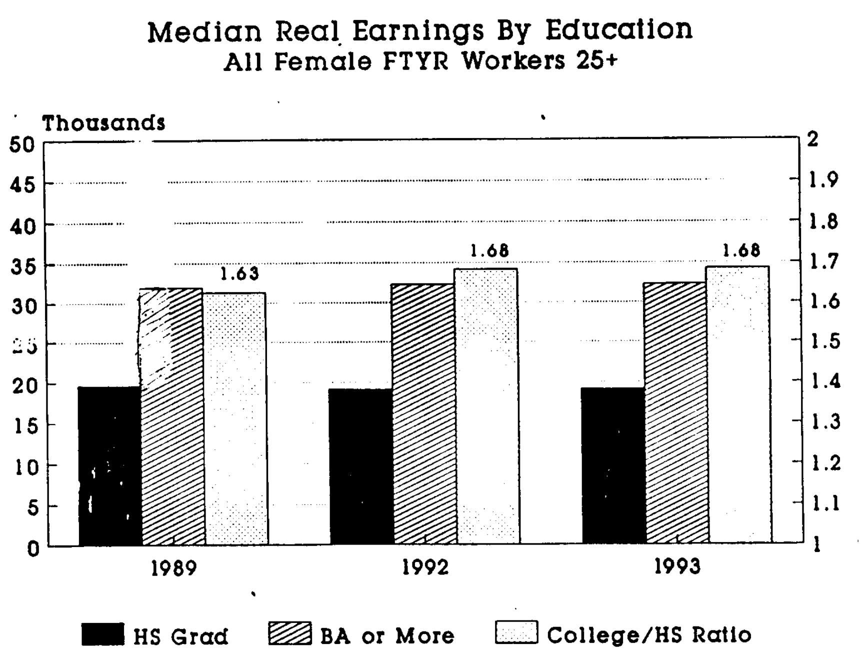


FIGURE 5b



1989 figures are 1980 Census weights.

FIGURE 6a: Wage Rate Effects of Skills for Males (1 Pop SD)

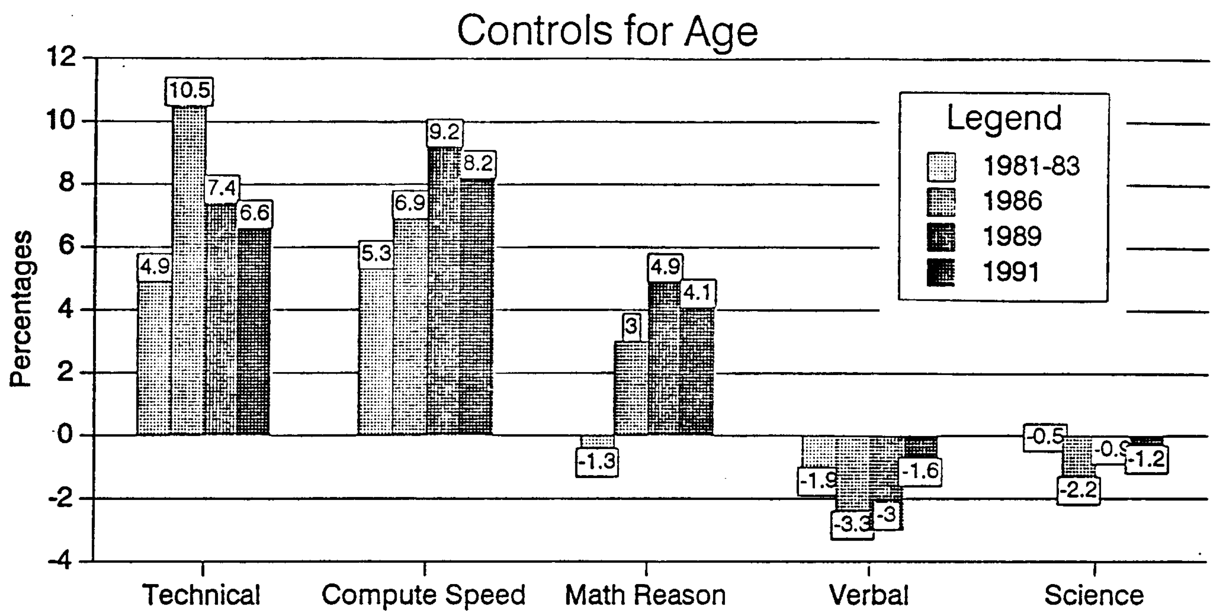


FIGURE 6b: Wage Rate Effects of Skills for Females (1 Pop SD)

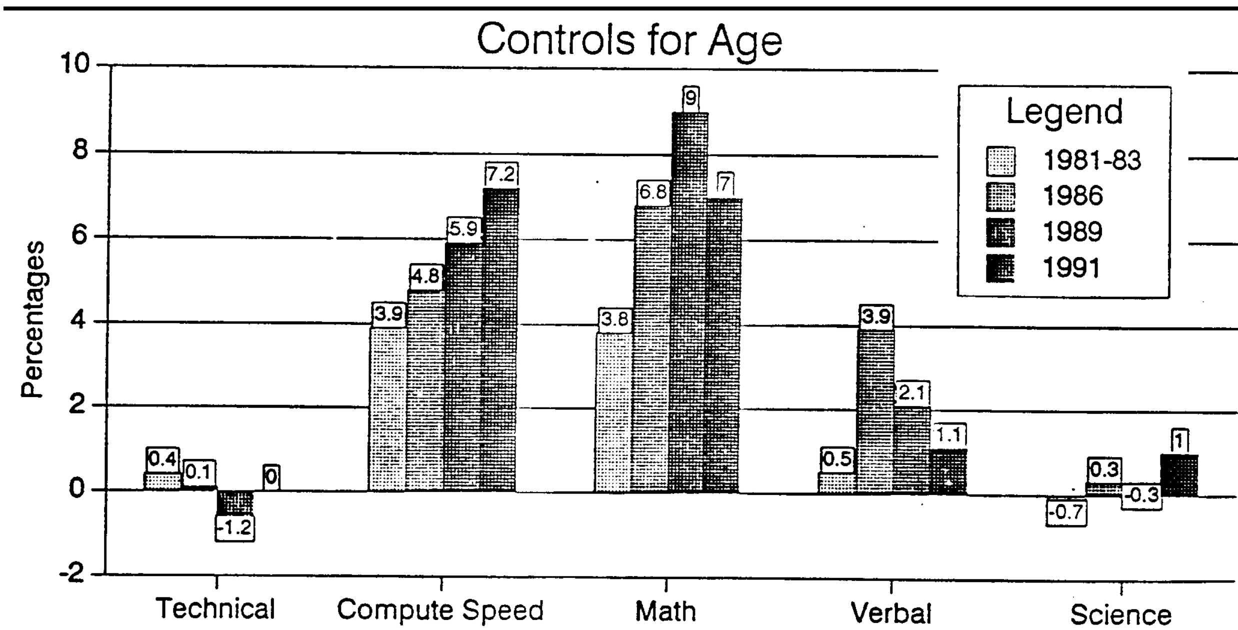


FIGURE 6c: Earnings Effects of Skills for Males

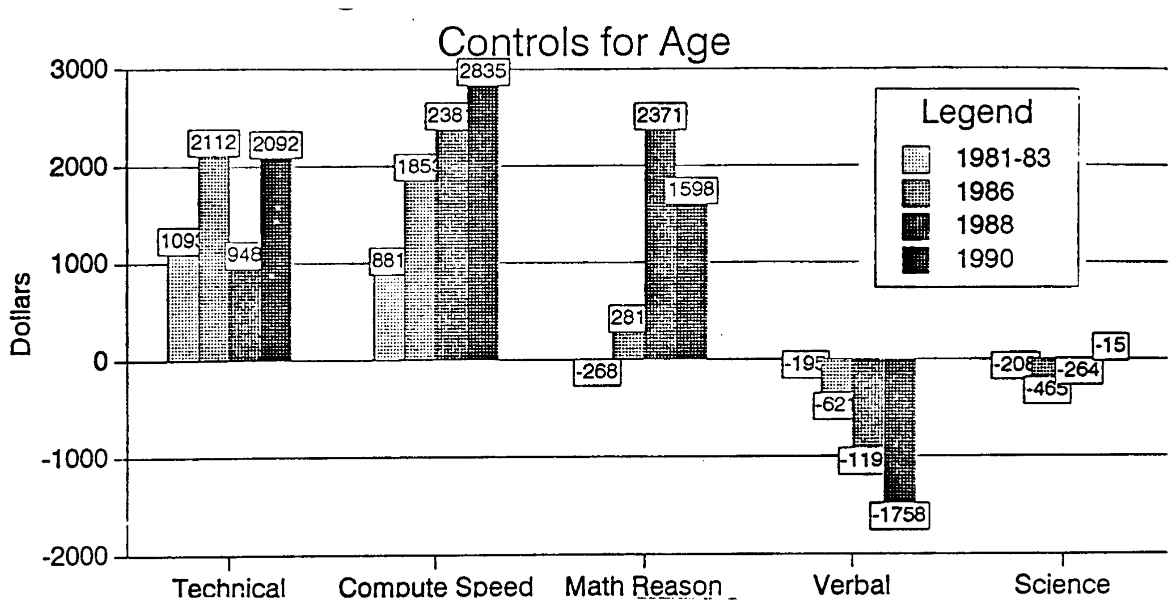


FIGURE 6d: Earnings Effects of Skills for Females

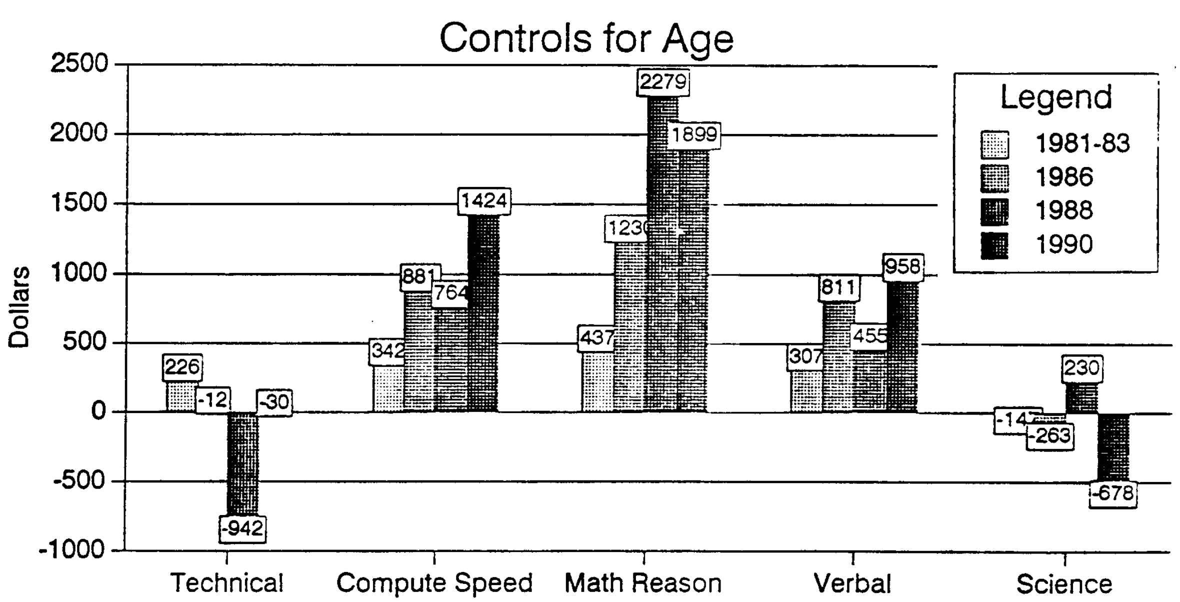


FIGURE 7: Effects of Skills on Productivity in Non Clerical-Non Combat Jobs

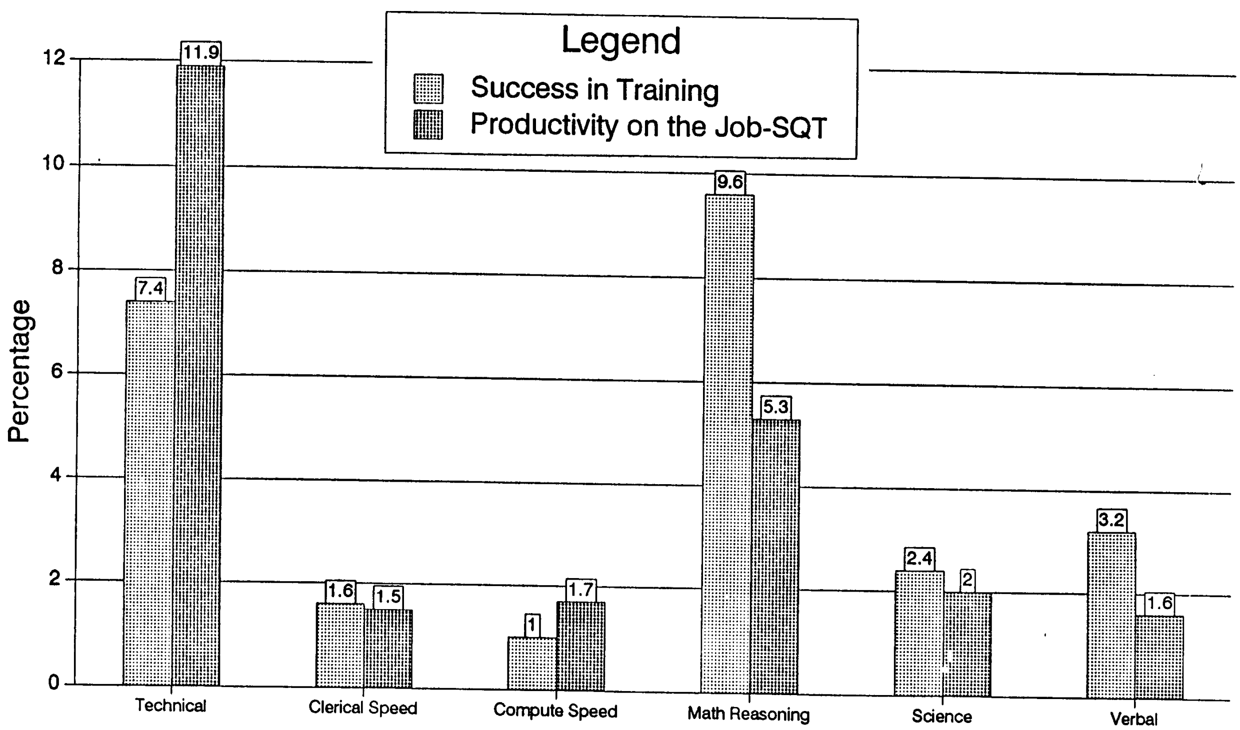


FIGURE 8: Effects of Skills on Productivity in Clerical Jobs

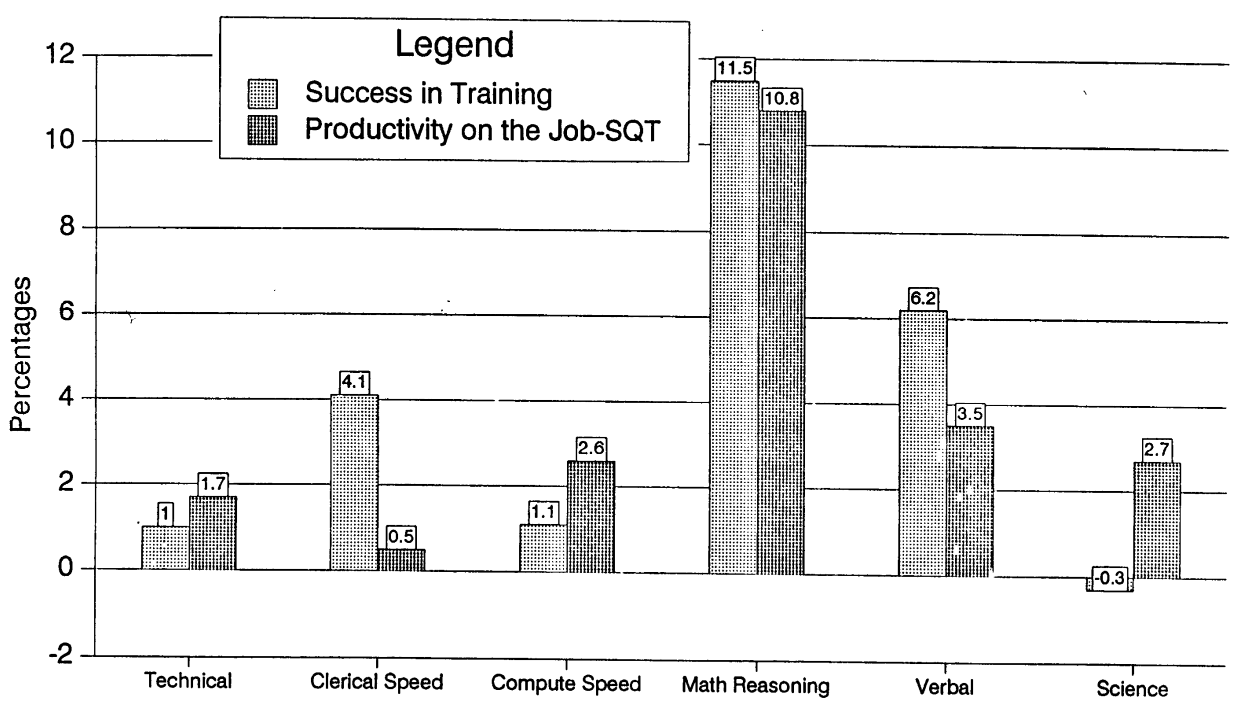
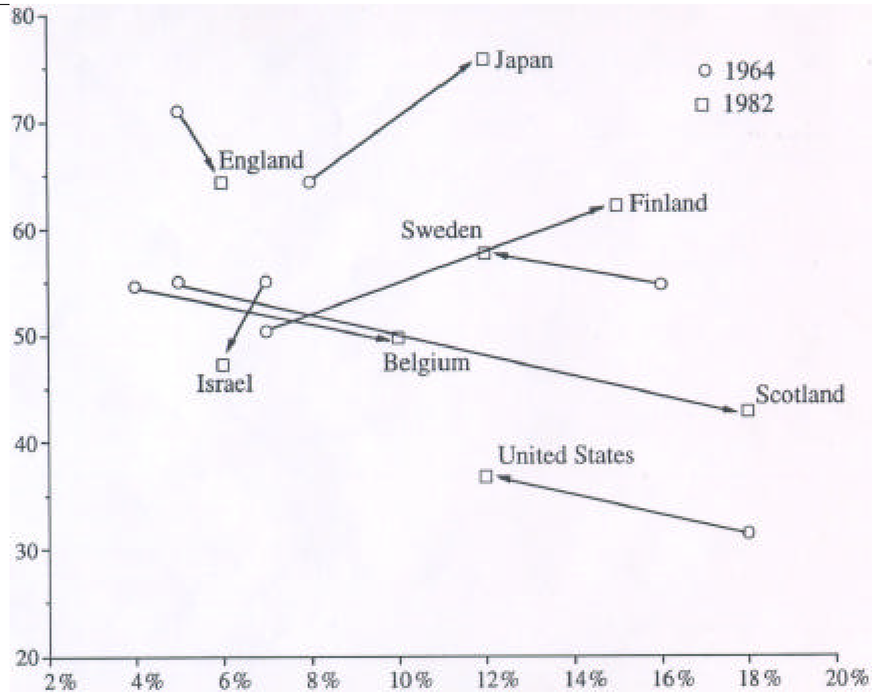
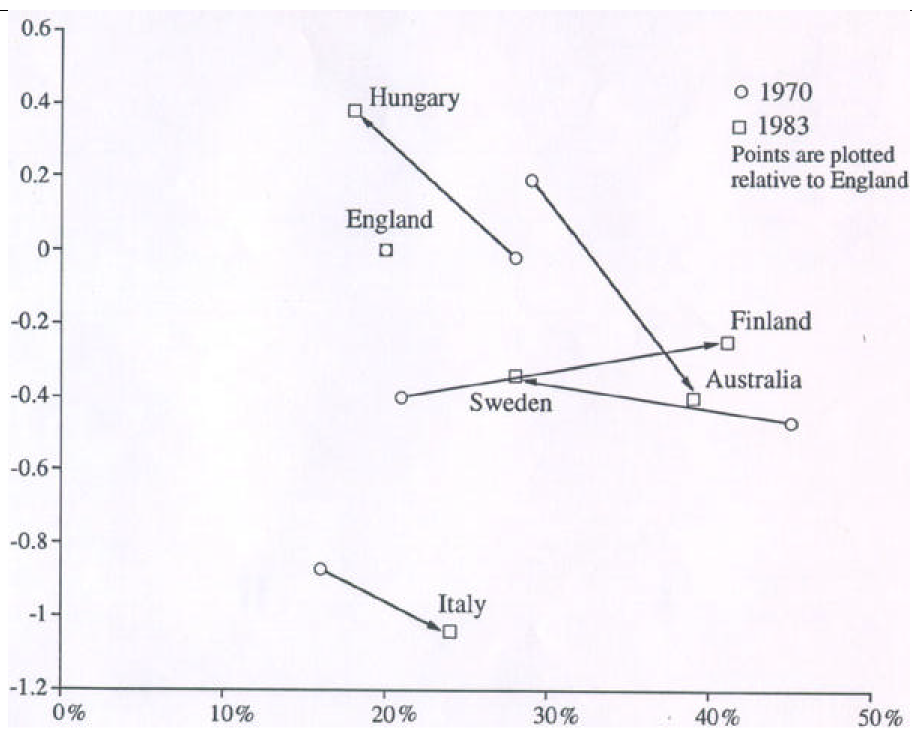


Figure 9: Mathematics at the End of High School



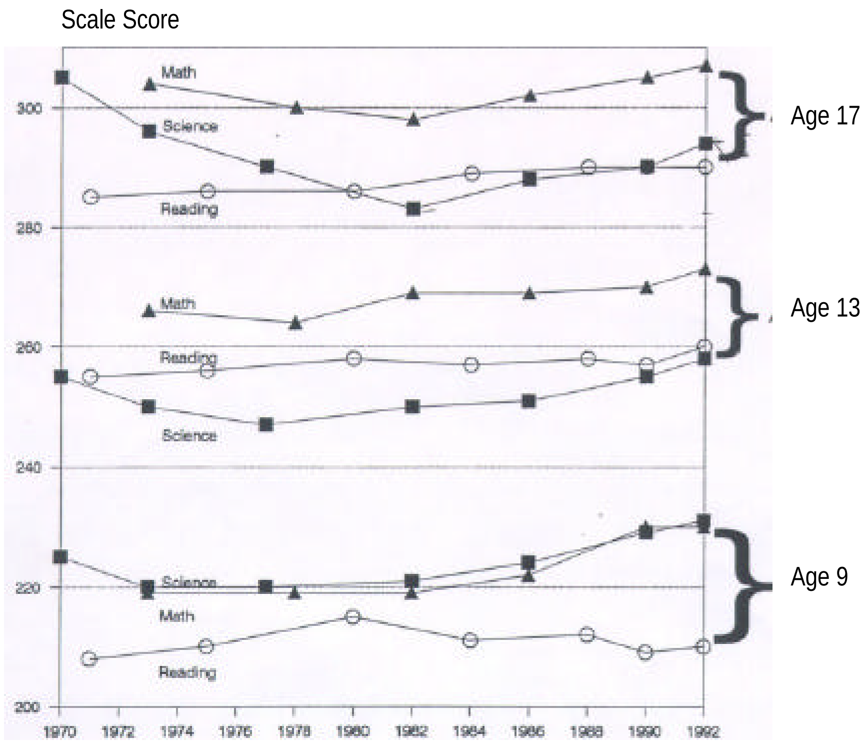
Percent of Age Cohort Taking Advanced Math

Figure 10: Science at the End of High School



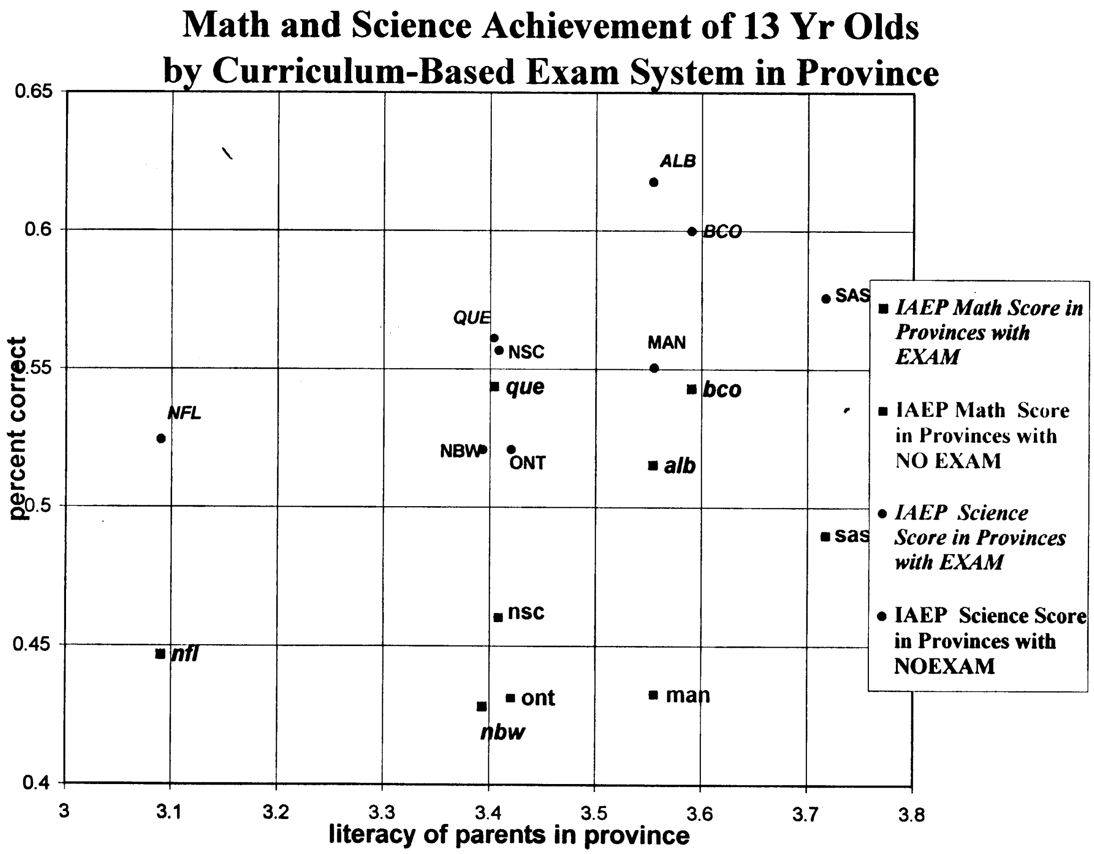
Percent of Age Cohort Taking Advanced Math

Figure 11: Trends in Average U.S. Achievement in Science, Mathematics, and Reading



Source: Mullis et al. (1994) and the National Assessment of Educational Progress (NAEP).

Figure 12:


Math and Science Achievement of 13 Yr Olds
by Curriculum-Based Exam System in Province
percent correct
literacy of parents in province
0.65
0.6
0.55
0.5
0.45
0.4
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
ALB
BCO
SAS
QUE
NSC
MAN
que
bco
NFL
NBW
ONT
alb
sas
nsc
nfl
ont
man
nbw
IAEP Math Score in Provinces with EXAM
IAEP Math Score in Provinces with NO EXAM
IAEP Science Score in Provinces with EXAM
IAEP Science Score in Provinces with NOEXAM