How Important Are the Cognitive Skills of Teenagers in Predicting Subsequent Earnings?

Richard J. Murnane
John B. Willett
Yves Duhaldeborde
John H. Tyler

Abstract

How important are teenagers' cognitive skills in predicting subsequent labor market success? Do cognitive skills pay off in the labor market only for students who go to college? Does college benefit only students who enter with strong basic skills? These questions are often parts of current policy debates about how to improve the earnings prospects for young Americans. This paper addresses these questions using two longitudinal data sets with earnings information from the mid-1980s and early 1990s. It shows that the same evidence can be used to support the claim that cognitive skills are important determinants of subsequent earnings, and that the effect of cognitive skills is modest. It also shows that while some evidence indicates that college pays off more for students who enter with strong cognitive skills than for students who enter with weaker skills, the bulk of the evidence does not support this conclusion. © 2000 by the Association for Public Policy Analysis and Management.

INTRODUCTION

Over the last 20 years, inequality in the earnings of American workers has increased markedly. This is reflected in both an increase in education-related earnings differentials and an increase in earnings inequality among individuals with the same demographic characteristics and educational attainments (Gottschalk, 1997; Katz and Autor, 1999; Katz and Murphy, 1992; Levy and Murnane, 1992). Many of the explanations proposed for these trends focus on a growing role for cognitive skills in determining labor market outcomes. For example, in 1996, *The Wall Street Journal* published editorials entitled "The Undereducated American" and "The Math Gap." The argument was that the increase in earnings inequality stemmed from an increase in the economic payoff to cognitive skills. This economic argument was also a theme in the highly publicized 1983 document, *A Nation at Risk,* which called for dramatic improvements in U.S. education. The same theme is central to the call for standards-based education reforms made in several recent books (Marshall and Tucker, 1993; Tucker and Codding, 1998).

The view represented in The Wall Street Journal editorials has not gone unchallenged. In *Who Gets Ahead?*, Christopher Jencks (1979) argues that cognitive skills play only a modest role in explaining why some American workers earn more than others. In "The Skills Myth," David Howell (1994) argues that an increase in the demand for

Manuscript received October 1998; revise and resubmit recommended January 1999; revision received February 2000, paper accepted February 2000.

Journal of Policy Analysis and Management, Vol. 19, No. 4, 547–568 (2000)

Published by John Wiley & Sons, Inc.

cognitive skills explains only a small part of the increase in earnings inequality; Mishel and Bernstein (1994) present a similar argument. In a recent paper published in an education journal, economist Henry Levin (1998) argues that standards-based education reforms cannot be justified on economic grounds.

In this paper, information from two nationally representative data sets is used to assess the role cognitive skills, as measured when students are high school seniors, play in explaining why some American workers in their late 20s and early 30s earn more than others of the same age. It also explores the importance of college as a mechanism through which high school students translate strong cognitive skills into later earnings advantages. It becomes clear that the same evidence can support quite different claims about the importance of cognitive skills.

It must be stressed at the outset that cognitive skills are not solely the result of genetic endowments. Both schooling and family investments increase skills (Jencks and Phillips, 1998; Winship and Korenman, 1997).

Recent Labor Market Trends and the Role of Cognitive Skills

Perhaps the most publicized trend in the distribution of earnings has been the increase in the college–high school earnings differential. This differential grew particularly rapidly during the first half of the 1980s for both males and females and has continued to grow, albeit at a slower pace, since the mid-1980s (Gottschalk, 1997; Katz and Autor, 1999). Since the early 1970s, inequality in earnings has also increased among individuals with the same demographic characteristics and educational attainments. Some evidence indicates that a growing demand for cognitive skills is at least part of the explanation for these trends. Murnane, Willett, and Levy (1995) show that the wage payoffs to basic math and reading skills were higher for 24-year-old males and females in 1986 than for comparable groups in 1978. Howell and Wolff (1991) report an increase in the payoff to academic skills during the 1970s and early 1980s. On the other hand, Bowles and Gintis (1998) find no evidence of an increase in the demand for cognitive skills over the past four decades.

In a much-cited paper, Blackburn, and Neumark (1993) present evidence that college might not be the answer for all high school students worried about the prospect of poor earnings. Using data on white males from the National Longitudinal Survey of Youth (NLSY) for the years 1979 to 1987, they find that the labor market payoff to college was greater for males who graduated from high school with strong cognitive skills than for graduates with weaker skills. Moreover, they find that the positive interaction between test score and educational attainment became stronger over the 1980s. Part of the agenda for the current paper is to examine whether the positive interaction between academic skill and years of completed schooling in predicting subsequent labor market outcomes is present in other data sets.

RESEARCH DESIGN

Data Sets

This research relied on data from two longitudinal surveys of American youth that were funded by the U.S. Department of Education: the National Longitudinal Survey of the High School Class of 1972 (NLS72) and High School and Beyond (HS&B).

NLS72 contains data on the education and labor market performance of 22,652 students who were high school seniors when first surveyed in 1972. Because the goal was to estimate the impact of skills and education on earnings in the mid-1980s, only the sub-sample of 12,841 individuals who participated in the fifth follow-up conducted in 1986 were included. The 1986 survey provides information on the 1985 labor market earnings of these participants. Excluded were: men and women whose 1985 earnings, expressed in 1990 dollars, were less than $1,000; those who did not graduate from high school; those who were farmers; those who did not complete the tests of reading and mathematics that were administered to participating high school seniors; and those who did not designate their race/ethnicity as white, black, or Hispanic (including the relatively few persons who classified themselves as "other").

The sophomore cohort of HS&B contains data on the education and labor market performance of a nationally representative sample of 14,825 individuals who were in the 10th grade in 1980. Here, the focus is on the 12,640 sophomores who were interviewed in 1992. This fourth follow-up interview provides information on 1991 labor market earnings. The same screens used in defining the NLS72 analytic samples were used to define the HS&B sample. Table 1A and Table 2A of the appendix show how the application of these screens reduced the numbers of observations from those in the original NLS72 and HS&B data sets to those in the analytical samples used here.

Two characteristics of the NLS72 and HS&B sophomore data sets make them valuable for studying the role that basic cognitive skills play in determining subsequent labor market earnings. First, students participating in these surveys completed tests of reading and mathematics skills in their senior year of high school. The mathematics test assessed mastery of relatively simple skills such as the ability to use fractions, decimals, and line graphs. The reading test assessed reading comprehension. The tests taken by participants contain many items common across data sets and the Educational Testing Service has provided scores on each test, computed using item-response theory, that are equatable across the two data sets. This comparison indicates whether a given difference in test score is associated with the same percentage difference in earnings in the two samples. Second, labor market earnings for participants are measured at least nine years after high school graduation in both data sets, a period long enough for participants to have completed their formal education and to have accumulated work experience.

The two data sets also have significant limitations. First, HS&B provides information only on annual earnings, and not hourly wages. Consequently, it is not possible to determine the extent to which a positive coefficient on a test score in an earnings function indicates that workers with higher test scores worked more hours a decade later than workers with lower high school scores, and the extent to which they obtained a higher hourly wage. Second, participants in the NLS72 were four years older (age 31) when their earnings were measured in 1985 than were HS&B participants (age 27) when their earnings were measured in 1991. A number of studies have shown that at least during their first decade in the labor market the experience-earnings profile is steeper for college graduates than for high school graduates (Murphy and Welch, 1990). Similarly, the experience-earnings profile is steeper for workers with strong cognitive skills than for those with weaker cognitive skills (Altonji and Pierret, 1996; Farber and Gibbons, 1996). Consequently, finding that the earnings payoff to educational credentials or cognitive skills is smaller for 27-year-old workers in 1991 than for 31-year-old workers in 1985 cannot be interpreted as meaning that the economic return to skills declined over the period 1985 to 1991.

Table 1 displays the problem. This research addresses two types of questions. The first is whether changes in the economy led to changes over time in the payoff to

Table 1. Confounding of cohort and age in the NLS72 and HS&B data sets.

	Year in which earnings were measured	
Age at which earnings were measured	1985	1991
27 years		HS&B
31 years	NLS72	

skills and educational credentials for demographically similar workers. For example, to determine whether cognitive skills affect the earnings of 27-year-olds in 1991 more than the earnings of 27-year-olds in 1985, data would be needed for both of the cells in the top row of Table 1. The second type of question is whether the payoffs to educational credentials and skills depend on age. For example, to determine whether the return to a college education is greater for 31-year-olds in 1991 than for 27-year-olds in that year, data would be needed for both cells in the second column of Table 1. Unfortunately, neither of the critical comparisons can be made cleanly with the NLS72 and HS&B data sets because cohort effects cannot be separated from age effects.

Analyses of CPS data show that education-related wage differentials and within-group inequality in wages did not decline between 1985 and 1991, and may have increased slightly over this period (cf. Gottschalk, 1997; Katz and Autor, 1999). Assuming that these patterns hold for earnings in these two data sets, the estimated earnings premiums associated with the educational attainment and cognitive skills for 27-year-old workers in 1991 can be interpreted as upper limits for what these differentials must have been for 27-year-old workers in 1985. Consequently, differences detected in these analyses between the economic returns to educational attainments and skills for 27-year-old workers in 1991 and for 31-year-old workers in 1985 are lower limits on the effects of age on earnings. It is this interpretation that is emphasized here.

Measures

Tables 2, 3, and 4 provide statistics describing the distributions of key variables used in our analyses. Sample weights were used in computing these statistics.

Race and Ethnicity

Table 2 illustrates changes that took place between 1972 and 1982 in the demographic composition of the nation's student population. Among both males and females, the percentage of non-Hispanic white students declined during this decade, and the percentages of black students and Hispanic students increased.

Educational Attainment

A first look at the distribution of educational attainments for these analytic samples shows patterns similar to those found in census-based tables describing the educational

Table 2. Descriptive statistics on the race/ethnicity and educational attainment of study participants, by gender and data set.

Race/Ethnicity	Males		Females	
	NLS72 (*n*=3645)	HS&B (*n*=3798)	NLS72 (*n*=3256)	HS&B (*n*=3729)
White	0.88	0.77	0.84	0.78
Black	0.07	0.10	0.11	0.12
Hispanic	0.06	0.13	0.06	0.10
Highest educational attainment				
High school graduate	0.44	0.50	0.42	0.43
Some college	0.26	0.21	0.30	0.25
Bachelor's degree	0.20	0.25	0.20	0.27
Postgraduate degree	0.10	0.05	0.09	0.05

attainments of young American adults. Slightly fewer than half of the young adults in these samples had obtained no post-secondary education. Another quarter had earned some college credits, but not a four-year degree. About a quarter earned at least a bachelor's degree.

A closer look at Table 2 suggests the importance of the four-year difference in age between the NLS72 samples and the HS&B samples. This is most evident in the percentage of the samples that had obtained a postgraduate education credential. Only 5 percent of the males and 5 percent of the females in the HS&B analytic samples had obtained a postgraduate credential. In contrast, 10 percent of the males and 9 percent of the females in the NLS72 analytic samples had such a credential. The age difference between the NLS72 and HS&B samples could also explain why a smaller percentage of both males and females in the HS&B analytic sample were in the college group than was the case in the NLS72 sample. In 1991, 10 percent of 25- to 29-year-old Americans and 7 percent of 30- to 34-year-old Americans were enrolled in an institution of higher education.[1] These figures suggest that the sample distribution of educational attainment for 27-year-olds does not provide accurate information on the eventual educational attainments of this cohort.

[1] We calculated the percentages of particular age groups enrolled in institutions of higher education using data from the following sources: Table 171. "Total fall enrollment in institutions of higher education, by attendance status, sex, and age: Fall 1970 to Fall 2006 (in thousands)." p. 178, National Center for Education Statistics, *Digest of Education Statistics 1996*; Table 14. "Resident Population, by Age and Sex: 1980 to 1996 (in thousands except as indicated...)." p. 15 in *Statistical Abstract of the United States 1997* (Bureau of the Census, 1997).

Measures of Cognitive Skills

Table 3 provides means and standard deviations for the math and reading scores of high school seniors in the NLS72 and HS&B analytic samples, by gender and by race/ethnicity within gender. One striking pattern is that the average reading and math scores of both male and female high school seniors in the HS&B analytic sample, who graduated from high school in 1982, are consistently lower than the average reading and math scores of the comparable groups in the NLS72 analytic sample, which graduated in 1972.[2]

Part of the decline stems from the changing demographic composition of the American student population. As Table 2 indicates, the percentage of males and females who are black or Hispanic is larger in the HS&B analytic sample than in the NLS72 sample. The second panel of Table 3 shows that in all analytic samples, the average reading and math scores of black high school seniors and Hispanic seniors are lower than the average scores of white seniors.

The changing racial/ethnic mix of American high school students does not explain all of the test score decline, however. Table 3 also shows that, with one exception, the average reading and math scores of 1982 high school seniors in every racial/ethnic group are lower than the average scores for 1972 high school seniors. The one exception is that black females in the HS&B analytic sample have higher average math scores than black females in the NLS72 analytic sample.

Table 3. Sample means (and standard deviations) of cognitive skill scores by gender, type of skill, and data set, for all participants and for sub-samples defined by race/ethnicity.

	Males				Females			
	Math		Reading		Math		Reading	
	NLS72	HS&B	NLS72	HS&B	NLS72	HS&B	NLS72	HS&B
All	14.11 (7.33)	12.55 (7.43)	10.13 (4.94)	8.63 (5.11)	12.55 (7.23)	12.01 (6.98)	10.30 (4.86)	8.56 (5.07)
White	14.80 (7.11)	13.99 (7.03)	10.57 (4.73)	9.47 (5.00)	13.64 (6.80)	13.36 (6.59)	10.97 (4.64)	9.42 (4.93)
Black	7.99 (6.94)	7.39 (6.55)	7.04 (5.71)	6.03 (4.39)	6.09 (6.23)	7.11 (5.93)	6.09 (4.19)	5.43 (4.09)
Hispanic	10.56 (6.76)	8.16 (6.83)	6.86 (4.67)	5.71 (4.53)	8.54 (7.44)	7.48 (6.48)	8.22 (4.76)	5.74 (4.62)

[2] Scores on other tests, including the SAT, declined over the 1970s (College Entrance Examination Board, 1977). The average score of 17-year-olds on the math test that is part of the National Assessment of Educational Progress (NAEP) declined by about one-sixth of a standard deviation between 1973 and 1982. While the average NAEP reading score for 17-year-olds did not decline over the 1970s (Mullis et al., 1994), there are reasons to question trends in NAEP test scores over this period (Koretz, 1987).

In the empirical work described in this paper, the math score was used as the measure of cognitive skills.[3] It is important to keep in mind that the math score measures reading comprehension as well as mastery of basic mathematics, as indicated by the high correlations between the math and reading scores—correlations that range from 0.65 to 0.70.

Table 4. Sample means (and standard deviations) of annual earnings in 1990 dollars by gender and data set, for all participants and for sub-samples defined by highest educational attainment and race/ethnicity.

	Males		Females	
Annual Earnings (1990 $)	NLS72 (n=3645) age = 31	HS&B (n=3798) age = 27	NLS72 (n=3256) age = 31	HS&B (n=3729) age = 27
All	31,460 (16,855)	24,605 (12,882)	19,493 (12,745)	19,264 (10,829)
By Highest Educational Attainment:				
High school diploma	27,656 (14,652)	22,371 (11,138)	15,389 (9,870)	16,466 (9,812)
Some college	31,683 (16,559)	23,431 (13,618)	19,663 (11,632)	18,931 (10,248)
Bachelor's degree	35,234 (16,394)	28,640 (12,200)	24,165 (14,600)	22,748 (10,794)
Postgraduate degree	40,079 (21,818)	31,467 (20,179)	28,030 (15,799)	26,049 (13,639)
By Race/Ethnicity:				
White	32,045 (17,187)	25,376 (13,233)	19,500 (12,878)	19,614 (10,754)
Black	26,482 (13,286)	21,433 (11,471)	19,607 (12,177)	18,699 (9,495)
Hispanic	28,159 (13,753)	22,565 (11,145)	19,176 (11,818)	17,264 (12,529)

[3] In preliminary analyses, we fitted regression models that included both the math score and the reading score as measures of cognitive skill, as well as models that included only one of the two scores. For each sample, the pattern was the same. The math score was consistently a stronger predictor of subsequent earnings than was the reading score. When both scores were included simultaneously in a model, the coefficient on the math score was positive and statistically significant, while the coefficient on the reading score was either insignificant or negative. The simple correlation coefficients between the math score and subsequent earnings and between the reading score and subsequent earnings are as follows: 0.25 and 0.19 for NLS72 males; 0.23 and 0.18 for NLS72 females; 0.20 and 0.13 for HS&B males; and 0.26 and 0.19 for HS&B females.

Earnings

The average constant dollar earnings of males in the NLS72 analytic sample were \$31,460; the comparable figure for females was \$19,493 (Table 4).[4] The average earnings of both males and females in the HS&B sample were lower, \$24,605 and \$19,264, respectively. To a large extent this reflects the four-year difference in age between the two samples (31 for NLS72; 27 for HS&B). As Murphy and Welch (1990) have shown, the experience-earnings profile tends to be quite steep during the late 20s, albeit more so for college graduates than for high school graduates.

The figures in Table 4 on average earnings by highest educational attainment and by race/ethnicity show patterns similar to those present in Current Population Survey (CPS) data. Educational attainment is positively related to average earnings in all four samples. At the same time, the variation in earnings is very large among both males and females with the same educational attainment. With one exception, the average earnings of black workers and Hispanic workers are lower than the average earnings of white workers in each sample. The exception is that the average earnings of black females in the NLS72 sample are slightly higher than the average earnings of white females in that sample.

STATISTICAL ANALYSES

Separate regression models were used for males and females, with sample weights fitted to all models. Standard errors were estimated using the Huber/White procedure to take account of clustering of students within schools.[5]

RQ #1: How important are the basic cognitive skills of high school seniors in predicting their earnings a decade or so later?

RQ #1 was addressed by fitting and comparing two regression models. Model #1, the baseline model, represented log-earnings as a function of race/ethnicity, years of labor force experience (and its square), and a set of family background characteristics that included parents' educational attainment, number of siblings, and the region of the country in which the respondent attended high school.[6] Model #2 added the high school senior's math score to the baseline model.[7, 8]

[4] We used the Consumer Price Index for All Urban Consumers (CPI-U) price deflator to express all earnings figures in 1990 dollars.

[5] The design of the NLS72 and HS&B samples clusters members of each of our analytic samples within approximately 900 high schools.

[6] Korenman and Winship (1995) report that using data on siblings to control for family background produces results close to those obtained with direct measures of family background.

[7] In preliminary analyses, we fitted regression models that included interactions between math score and indictors of race/ethnicity as predictors of log earnings. In none of the four analytic samples could we reject the null hypothesis that the interaction terms were jointly zero (at the 0.10 level). This led us to conduct all analyses reported in this paper without interactions between math score and race/ethnicity.

[8] Several predictors in our regression models, including the math score and the indicators of educational attainment, are measured with error. For example, the estimated reliability of the math score is 0.87 for males in the NLS72 sample, 0.85 for females in that sample, 0.91 for males in the HS&B sample, and 0.89 for females in that sample (Rock et al., 1985, p. 49). We decided not to include reliability corrections for several reasons. First, we did not have estimates of the reliabilities of the educational attainment indicators. Second, Kane, Rouse, and Staiger (1999) present evidence that the standard reliability corrections to deal with measurement error in indicators of educational attainment are flawed. Third, with available software, we could not allow for the clustering of observations within schools and simultaneously correct for measurement errors in predictors involving interactions between the math score and indicators of educational attainments.

RQ #2: How much of the effect of cognitive skills on subsequent earnings takes place through the indirect mechanism that high school graduates with strong basic skills are the most likely to complete college, an investment that pays off in the labor market?

Two additional regression models were fitted to address this question. Model #3 added indicators of educational attainment to the baseline model. Model #3 is essentially the Mincerian earnings function common in human capital research. Model #4 added math score to Model #3. A key comparison is between the size of the coefficient on math score in Model #2, which is an estimate of the total effect of basic cognitive skills on subsequent earnings, and the coefficient on math score in Model #4, which is an estimate of the direct effect.

RQ #3: Is the payoff to postsecondary education greater for high school graduates with strong basic cognitive skills than for those with weaker cognitive skills?

This question was addressed by fitting Model #5, which added to Model #4 the two-way interaction between math score and a continuous measure of educational attainment. The critical question is whether the coefficient on this interaction term is positive.

An important caveat is that these analyses are descriptive. For example, the authors show that those high school students with weak cognitive skills who completed college earn more a decade later than observationally similar high school students with weak cognitive skills who did not go to college. Since no attempt was made to model the process determining which high school seniors go on college and which do not, it would be inappropriate to interpret this finding as evidence that high school seniors with weak cognitive skills who did not go to college would have as high a payoff to college if they had enrolled as did those seniors with weak skills who did choose to enroll in college and subsequently did graduate from college.

RESULTS

RQ #1: How important are the basic cognitive skills of high school seniors in predicting their earnings a decade or so later?

The coefficient on math score for NLS72 males (Model #2 in the top left panel of Table 5) indicates that a one-point difference in the math score of male high school seniors in 1972 is associated with a 2 percent difference in annual earnings at age 31.[9] The coefficient on math score for HS&B males (Model 2 in top right panel of Table 5) indicates that a one-point difference in the math score of male high school seniors in 1982 is associated with a 1.5 percent difference in annual earnings at age 27. The likely explanation for the difference in the size of the coefficients is that the NLS72 sample was four years older than the HS&B sample when earnings were measured, and the role of cognitive skills in determining earnings increases during the first years in the labor market (Altonji and Pierret, 1996; Farber and Gibbons, 1996).

What does the evidence from the fitted models indicate about the importance of high school seniors' basic cognitive skills in predicting subsequent earnings? One could argue that the effect is quite large. Addition of high school seniors' math score to the model predicting earnings a decade or so after high school graduation increased

[9] We calculated the impact of the coefficient, β, on earnings, as $e^{\beta}-1$. Note that while $(e^{\beta}-1)$ is approximately equal to b for very small values of β, such as 0.02, this is not the case for larger values of β, such as 0.20.

the explanatory power of the models fitted on data for males by at least 50 percent. Since the standard deviation of math score for NLS72 males is greater than seven points, the predicted annual earnings of a 31-year-old male who graduated from high school with strong cognitive skills (a math score one standard deviation above the mean) are about 30 percent higher than those of a 31-year-old male who graduated from high school with very weak cognitive skills (a math score one standard deviation below the mean).

Another argument supporting the importance of cognitive skills is that differences between the math scores of black males and those of white males explain more than 50 percent of the black–white earnings gap for 27-year-old males in 1991 and more than 90 percent of the gap for 31-year-old males in 1985.[10] The point estimates also imply that the predicted earnings of Hispanic males relative to those of white males are higher in models that account for differences in math scores than in models that do not.

Table 5. Regression coefficients (and standard errors) from models for addressing the first research question, by data set and model number.

Population	Predictor	NLS72		HS&B	
		Model #1	Model #2	Model #1	Model #2
Males	Black	–0.119~ (0.064)	–0.010 (0.054)	–0.120** (0.044)	–0.043 (0.044)
	Hispanic	–0.017 (0.066)	0.038 (0.066)	–0.088 (0.037)	–0.018 (0.036)
	Math		0.020** (0.003)		0.015** (0.002)
	R^2	0.085	0.131	0.051	0.079
	n	3645	3645	3798	3798
Females	Black	0.172** (0.065)	0.251** (0.064)	0.170** (0.041)	0.249** (0.043)
	Hispanic	0.107* (0.054)	0.159** (0.052)	–0.046 (0.046)	0.030 (0.046)
	Math		0.013** (0.003)		0.017** (0.002)
	R^2	0.164	0.178	0.132	0.156
	n	3256	3256	3729	3729

Notes: $p<0.10$=~, $p<0.05$=*, $p<0.01$=**

[10] See Johnson and Neal (1998) for a discussion of the role of differences in cognitive skills in explaining black–white earnings differentials among men.

Another relevant metric is the earnings increase that educational reform programs might bring about. Henry Levin (1998) concluded that an effective educational reform program may increase test scores by as much as a quarter of a standard deviation. The coefficient on the math score in Model #2 for NLS72 males (0.02) implies that a successful educational reform might result in an annual earnings increase of 3.7 percent.[11] If this earnings increase were retained for each of the 35 years that an American male typically works, the present discounted value of the earnings increase would be approximately $22,000, a considerable sum.[12] Thus, *there are several ways to argue that differences in cognitive skills are important in* explaining differences in earnings.

The evidence in Table 5 can also support a quite different conclusion about the importance of cognitive skills in determining labor market outcomes. The information on family background, work experience, and math score explains only 13 percent of the variance in the log earnings of 31-year-old males in 1985 and only 8 percent of the variation in log earnings among 27-year-old males in 1991. For both samples, there is substantial variation in annual earnings around the fitted trend line at each value of math score. This means that the conditional earnings distributions of males with different math scores overlap considerably. For instance, if an educational reform program did increase the skills of participating male high school seniors by one quarter of a standard deviation (1.83 points), and thereby did produce an increase in their subsequent predicted mean earnings of 3.7 percent, it would still be the case that 47 percent of the participants would have earnings below the average earnings of nonparticipants.[13] The lesson here is that conclusions about the importance of cognitive skills in determining subsequent earnings depend not only on the evidence, but also on the emphasis one chooses in interpreting it.

The estimated coefficients on the math scores in the fitted models for females are of the same order of magnitude as the analogous coefficients for males. However, there are some differences. *A one point difference in high school math score for* NLS72 females is associated with a 1.3 percent difference in earnings at age 31—an effect approximately one-third smaller than the predicted effect for males. A one-point difference in high school math score for HS&B females is associated with a 1.7 percent difference in log earnings at age 27, a larger effect than that for 31-year-old females in 1985. If the evidence for males (Altonji and Pierret, 1996; Farber and Gibbons, 1996) that the effect of skills on earnings increases during the first decade in the labor market also pertains to females, the pattern indicates that basic cognitive skills are more important in predicting subsequent earnings for females in the high school class of 1982 than they were for females who graduated from high school a decade earlier.

[11] The standard deviation in the math score for NLS72 males is 7.33 points. Hence one quarter of a standard deviation is 1.83 points. The product of 1.83 and 0.02 (the coefficient on the math score) is 0.037.

[12] The "back-of-the-envelope" estimate of a $22,000 present discounted value is calculated as follows. In our sample of NLS72 males, the average annual earnings at age 31 is $31,460. An increase of 3.7 percent amounts to $1,164. Assuming this increase in annual real earnings is constant over 35 years, and assuming a real discount rate of 0.04, the present discounted value is $21,726.

[13] Under the homoscedasticity assumption on OLS regression analysis, the standard deviation of the residuals (here 0.572) describes the vertical scatter of the datapoints around the fitted trend line at each value of the math predictor. Hence, at any value of math score, the data points have a normal distribution with mean equal to the predicted value of log-earnings (at that value of math score) and a standard deviation of 0.572. For males whose math scores are one quarter standard deviation (1.83 points) apart, the difference in predicted log-earnings is 0.037 (0.020 x 1.83). Converting this difference into a z-score of 0.065 (=0.037/0.572), we can use the normal theory assumption underlying OLS regression analysis to compute the overlap in two standard normal distributions whose centers are 0.065 apart. From a table of normal deviates, we then compute that 47.4 percent of males with the higher math score will have earnings that fall below the average value of the log-earnings among males with the lower score.

RQ #2: How much of the effect of cognitive skills on subsequent earnings takes place through the indirect mechanism that high school graduates with strong basic skills are the most likely to complete college, an investment that pays off in the labor market?

The top half of Table 6 presents coefficients of interest from Models #3 and #4 fitted with data on males from the NLS72 and HS&B analytic samples. The estimated coefficients for Model #3 indicate that, controlling for years of work experience and family background, the predicted annual earnings of 31-year-old male college graduates in 1985 were 41 percent higher than those of male high school graduates in that cohort. The corresponding college/high school earnings differential for 27-year-old males in 1991 is approximately the same size (36 percent). Murphy and Welch's (1990) research suggests that the college/high school earnings premium will rise as the 27-year-old college graduates in the HS&B sample gain more labor market experience.

That age-earnings profiles are steeper the more formal education workers have is especially evident in the relative earnings of males with a postgraduate education credential. The predicted annual earnings of 31-year-old males in 1985 who have a postgraduate education credential are approximately 61 percent above those of male high school graduates in the same cohort. The annual earnings of 27-year-old males in 1991 with a postgraduate credential are only 45 percent above those of high school graduates in the same cohort. A recent paper by Katz and Autor (1999) shows that the wage differential between males with a postgraduate education credential and those whose highest educational credential is a high school diploma rose during the 1980s. This evidence suggests that by age 31 the earnings premium of HS&B males with a postgraduate credential will be higher than the 61 percent premium experienced by 31-year-olds in 1985.

Comparison of the size of the coefficient on the math score in Model #2 of Table 5, which does not contain indicators of educational attainment, with the magnitude of the math score in Model #4 of Table 6, which does contain education indicators, shows the extent to which the payoff to basic cognitive skills comes through the mechanism of investments in postsecondary education. For both NLS72 males and HS&B males, the coefficient on the math score in Model #4 is approximately one-third smaller than the coefficient on the math score in Model #2. Thus, for males, approximately two-thirds of the total effect of basic cognitive skills on subsequent earnings consists of direct effects—differences in earnings among workers with different cognitive skills as measured in high school, but the same educational attainments. One-third of the total effect of cognitive skills on subsequent earnings is an indirect effect through the mechanism of educational attainments—males with stronger cognitive skills are more likely than males with weaker skills to complete college and a college degree pays off in the labor market.

The patterns pertaining to women displayed in the bottom panel of Table #6 are similar to those for men in many respects, but different in others. The payoffs to college and to postgraduate education are particularly sensitive to age for women. Controlling for family background and work experience, the predicted annual earnings of 31-year-old female college graduates in 1985 were 54 percent higher than those of 31-year-old females whose highest educational attainment was a high school diploma. Among 27-year-old females in 1991, the corresponding differential was considerably smaller, 40 percent. The earnings premium associated with a postgraduate education credential is even more sensitive to age. The predicted earnings of 31-year-old females in 1985 who had a postgraduate education credential were 86 percent greater than those of high school graduates of the same age; the corresponding differential for 27-year-old females in 1991 was 66 percent.

Table 6. Regression coefficients (and standard errors) from models for addressing the second research question, by data set and model number.

		NLS72		HS&B	
Population	Predictor	Model #3	Model #4	Model #3	Model #4
Males	Black	–0.117* (0.057)	–0.047 (0.054)	–0. 079~ (0.044)	–0.043 (0.044)
	Hispanic	–0.001 (0.072)	0.031 (0.071)	–0.047* (0.036)	–0.017 (0.035)
	Some college	0.150** (0.035)	0.092** (0.033)	0.007 (0.031)	–0.032 (0.032)
	Bachelor's degree	0.343** (0.039)	0.249** (0.039)	0.307** (0.031)	0.236** (0.032)
	Postgraduate degree	0.474** (0.075)	0.357** (0.072)	0.372** (0.078)	0.284** (0.078)
	Math score		0.013** (0.002)		0.009** (0.002)
	R^2	0.142	0.157	0.100	0.107
	n	3645	3645	3798	3798
Females	Black	0.143** (0.053)	0.158** (0.053)	0.211** (0.039)	0.244** (0.042)
	Hispanic	0.112* (0.050)	0.122* (0.051)	–0.009 (0.045)	0.024 (0.045)
	Some college	0.201** (0.036)	0.193** (0.039)	0.119** (0.034)	0.094** (0.035)
	Bachelor's degree	0.435** (0.046)	0.421** (0.053)	0.336** (0.034)	0.276** (0.038)
	Postgraduate degree	0.621** (0.063)	0.602** (0.068)	0.508** (0.064)	0.432** (0.067)
	Math score		0.002 (0.003)		0.009** (0.002)
	R^2	0.217	0.217	0.175	0.180
	n	3256	3256	3729	3729

Notes: $p<0.10$=~, $p<0.05$=*, $p<0.01$=**

For females in the NLS72 sample, more than 80 percent of the total effect of basic cognitive skills on earnings at age 31 consisted of the indirect effect through the mechanism of educational attainment. In contrast, for females in the HS&B sample, more than half of the total effect of high school skills on earnings at age 27 consists of a direct effect. In other words, even among women in this sample who have the same educational attainments, a one standard deviation difference in high school math score is associated with an earnings differential of approximately 6 percent at age 27.

As with the first research question the available evidence can be used to support quite different arguments. For example, the evidence supports the argument that going to college is critical to translating the benefits of strong basic skills into labor market success. At the same time, there is evidence that even for high school graduates who do not go on to college, differences in basic skills mastery result in later differences in earnings.

RQ #3: Is the payoff to postsecondary education greater for high school graduates with strong basic cognitive skills than for those with weaker cognitive skills?

The specification of Model #4, used to address our second research question, assumes that the direct effect of the high school math score on later earnings is independent of subsequent educational attainments. As explained above, Blackburn and Neumark (1993) found that the payoff to college was greater for white males with relatively strong academic skills than for white males with weaker cognitive skills. Model #5 was fitted to investigate whether this pattern is also present in these data; Model#5 includes the interaction between the math score and a continuous measure of years of college coursework completed. The results are displayed in Table 7. At the bottom of this table, for each fitted model the result is listed of a one-tailed test of the null hypothesis that the coefficient on the interaction term is zero. A one-tailed test was used because the compelling alternative hypothesis is that the economic benefits of college are greater for students who enter with strong basic cognitive skills than for students who enter with weaker skills.

For one of the four samples, NLS72 males, the coefficient on the interaction term is positive and statistically different from zero. Moreover, the magnitude is economically significant. The predicted college/high school earnings differential, 31 percent, for males who entered college with a math score one standard deviation above the mean is 10 percentage points higher than the predicted college/high school earnings differential, 21 percent, for students who entered college with a math score one standard deviation below the mean.[14] This pattern is consistent with the Blackburn and Neumark findings.

The evidence for females in the NLS72 data set and for both males and females in the HS&B data set is quite different, providing no evidence that the economic benefits from college are greater for students who enter with strong skills than for those who enter with weak skills. In fact, in the two HS&B samples, the coefficient on the interaction term is negative.[15] Thus, in answering this question as well as the first two, there is evidence in either the NLS72 or HS&B databases to support quite different conclusions.

[14] These calculations are based on the coefficients for NLS72 males in Table 7 (Model #5). (Note that this model includes the main effect of math score as well as the interaction of math score and years of completed college.) As stated in Table 3, the average math score for NLS72 males is 14.11 and the standard deviation of the math score is 7.33. We also assume that a bachelor's degree is earned through four years of college enrollment.

[15] There are many alternative ways to parameterize the interaction between the math score and educational attainment. See, for example, Cawley, Heckman, and Vytlacil (1998). We explored a variety of specifications and found none that offered stronger evidence of a positive interaction effect.

Table 7. Regression coefficients (and standard errors) from models for addressing the third research question, by data set and model number.

Predictor	Males		Females	
	NLS72 Model #5	HS&B Model #5	NLS72 Model #5	HS&B Model #5
Black	−0.046 (0.055)	−0.045 (0.044)	0.159** (0.053)	0.245** (0.042)
Hispanic	0.026 (0.071)	−0.016 (0.035)	0.118* (0.052)	0.024 (0.045)
Some college	0.066~ (0.035)	−0.010 (0.033)	0.183** (0.039)	0.097** (0.037)
Bachelor's degree	0.150** (0.046)	0.299** (0.048)	0.374** (0.067)	0.285** (0.048)
Postgraduate degree	0.215* (0.085)	0.375** (0.092)	0.534** (0.085)	0.447** (0.081)
Mathematics score	0.010** (0.003)	0.011** (0.002)	0.001 (0.003)	0.009** (0.003)
Years of college * math	0.0014** (0.0004)	−0.0009~ (0.0005)	0.0008 (0.0006)	−0.0002 (0.0006)
R^2	0.161	0.109	0.218	0.180
n	3645	3798	3256	3729
p-value from test of the null hypothesis that the coefficient on years college * math score interaction is zero against the alternative hypothesis that the coefficient is greater than zero.	0.001	0.973	0.330	0.607

Notes: $p<0.10$=~, $p<0.05$=*, $p<0.01$=**

A METHODOLOGICAL PUZZLE?

The findings reported in this paper fit a pattern documented in previous research, namely, that information on test scores, educational attainment, and family background explain less than a third of the variation among individuals in labor market earnings. There are two classes of explanation for this pattern. The first is that skills, broadly defined, actually explain more of the variation in earnings than studies to date have shown. Among the limitations of existing studies are that the scores on multiple choice tests available in nationally representative data sets measure only some of the skills that matter to employers. For example, they do not measure interpersonal skills that are important in a wide range of jobs. Available test scores may not even measure well the cognitive skills they were designed to assess because participants in most national surveys have no incentive to work hard at the tests. A consequence of this view is that accurate information on a wide range of skills would explain more of the variation in labor market earnings than existing studies do.

An alternative explanation is that skills are only one determinant of earnings in today's labor markets. Other factors contributing to differences in earnings include labor market discrimination, union wage premiums, obstacles to labor market mobility, and variation in workers' taste for different types of jobs.

The two alternative explanations for the modest explanatory power of current studies of earnings variation have quite different policy implications. Adherents of the first view argue that improving education and training is the key to reversing the increasing earnings inequality trend, perhaps with greater attention to teaching a wide range of skills. Adherents of the second view argue for changes in labor market institutions, including stronger enforcement of anti-discrimination laws, the development of better labor market intermediaries to match workers with jobs, and efforts to revitalize labor unions.

SUMMARY AND DISCUSSION

Devoting time and effort to acquire cognitive skills during the schooling years eventually pays off in the labor market. In this respect, skill acquisition is similar to other investments. However, a respect in which mastering skills is different from many other investments is that it is typically not possible to borrow against future expected returns while allocating time to studying during the high school years. Consequently, sacrificing leisure or earnings to acquire cognitive skills makes sense only for adolescents with long time horizons. For students who encounter no adult role models who have acquired strong cognitive skills and parlayed them into good jobs, the payoff to school work may be especially hard to envision. Investing in skill acquisition becomes even more unlikely when students from low-income families are concentrated in low-quality schools. With poor instruction the time and effort required to master cognitive skills are greater than with good instruction.

The central point here is that linkages between skill acquisition and the economy go in both directions. Skills affect subsequent earnings. At the same time, the distribution of family income coupled with constraints on borrowing make it difficult for low-income families to enroll in high-quality schools, and may also make it more difficult for high school students from low-income families to project the payoff to skill acquisition.

Findings from this study can be used to demonstrate that cognitive skills are important determinants of subsequent earnings and to support the claim that the effect of cognitive skills is quite modest. Those who emphasize the modest role of cognitive skills can point out that in none of the samples did test scores and family background measures explain as much as 25 percent of the variation in annual earnings of 27- or 31-year-old workers. There is enormous variation in the earnings of workers with the same high school skills.

Those who want to emphasize the importance of cognitive skills can point out that the predicted earnings of a 31-year-old male who graduated from high school with strong cognitive skills are 30 percent higher than the predicted earnings of a 31-year-old demographically similar male who graduated with weak cognitive skills. They could also point out that the difference between the average test scores of black male high school seniors and white male high school seniors explains more than half of the difference between the average earnings of these groups a decade later. While they might concede that it is difficult to design and implement programs that increase students' cognitive skills, they could point to some programs that have had a remarkable effect on the test scores of low-income students.[16] Moreover, they could point out that, with the exception of the minimum wage and perhaps the Earned Income Tax Credit, there is much more support in the United States for programs to enhance skills than for programs to directly alter the distribution of incomes. Consequently, well-designed programs to improve skills are better bets than most politically feasible alternatives.

An important reason why students who graduate from high school with strong cognitive skills have higher subsequent earnings than students who leave high school with weak skills is that they are more likely to earn postsecondary education credentials, credentials with substantial and growing labor market rewards. This indirect return to cognitive skills consists of at least one-third of the total return. This pattern suggests that access to college is critical to enabling students to realize the full return on investing in skill mastery.

As the sticker price of college (tuition, room and board) continues to increase, the question arises whether students from low-income families can afford to go to college. A recent paper by Thomas Kane (1998) argues that grants and loans make college surprisingly affordable to students from low-income families. Yet the puzzle remains why relatively few academically able students from low-income families enroll in and graduate from college. Kane suggests that the explanation may lie in a lack of information. The rising sticker price of college is evident to most prospective students. The complexity of financial aid programs leaves many students unaware that their net cost of college, if they took advantage of all available aid, would be substantially below the sticker price. The implication is that making financial aid available is not enough. Students also need to be aware that college is affordable. Without college, the returns to skill investments are substantially lower than the returns with postsecondary education. Helping low-income students realize that college is affordable is a necessary part of creating incentives for them to invest the time during high school to master critical skills.

On the question of whether college pays off as well for students who graduate from high school with weak cognitive skills as for students who graduate with stronger skills, the evidence is not completely clear-cut. For three of the four samples, the results indicate that the answer is yes. For the fourth sample, NLS72 males, there are positive earnings returns to college for students who enroll with weak skills, but the predicted returns are higher for students who enter with strong skills.

In any case, the evidence must be interpreted carefully. Very few students who graduate from high school with weak cognitive skills subsequently graduate from college. In the HS&B sample of males, only 4 percent of males whose math scores were in the bottom quartile of the distribution subsequently graduated from college. In contrast, 60 percent of males in this cohort whose math scores were in the top quartile of the score distribution earned four-year college degrees.

The two data sets also provide some evidence that those students with low math scores who did graduate from college had academic strengths as high school seniors not indicated by their math scores. These students tended to have higher reading scores on average than did students with the same math scores who did not enroll in college.[17] Consequently, even though college did pay off for those relatively few low-

[16] For a description of such programs, see chapter 4 of Murnane and Levy, 1996. Also, see James Heckman (1999) who points especially to the value of interventions for young children.

[17] The evidence supporting this statement is that the partial correlation between years of completed college and high school reading score, controlling for high school math score, was positive and significantly different from zero for all four samples. One might argue that it is important to include these reading scores in the fitted models. However, as pointed out in an earlier note, the coefficient on the reading score was not positive and significantly different from zero for any sample in any model predicting log earnings that also included the math score.

scoring high school seniors who subsequently obtained a four-year degree, this does not provide reliable evidence about the likely consequences of programs aimed at inducing more low-scoring students to attend college.

The critical pattern is that the cognitive skills of high school seniors are strong predictors of subsequent educational attainments. This is one reason why seniors' math scores predict earnings a decade after high school graduation. Improving the cognitive skills of today's elementary and secondary school students is not a magic bullet for dramatically reducing earnings inequality in the United States. But it is an essential strategy for preparing students to enroll in and succeed in college, and increasingly postsecondary education credentials are necessary for economic success in the United States.

DATA APPENDIX

National Longitudinal Study of the High School Class of 1972 (NLS72) Sample Selection

The *NLS72* data used in this paper are taken from a national longitudinal survey of 22,652 individuals who were in the 12th grade in 1972. To be included in the analytic samples, males and females in the survey had to have participated in both the 1972 base year survey and in the fifth follow-up survey conducted in 1986. In Table 8 we tabulate the results of sample selection decisions that were made to create the final analytic samples of 3645 males and 3256 females used in this paper.

High School and Beyond Data

Sample Selection

The High School and Beyond (HS&B) data used in this paper are taken from a national longitudinal survey of 14,825 individuals who were in the 10th grade in 1980. To be included in the sample, males in the survey had to have participated in both the 1980 base year survey and in the fourth follow-up survey conducted in 1992. Table 9 below tabulates the results of sample selection decisions that were made to create the final analytic samples of 4397 males and 4121 females used in this paper.

The writing of this article was supported, in part, by the National Center for Postsecondary Improvement, under the Educational Research and Development Center program, agreement number R309A60001, CFDA 84.309A, as administered by the Office of Educational Research and Improvement (OERI), U.S. Department of Education. The findings and opinions expressed herein do not reflect the position or policies of OERI or the U.S. Department of Education.

The authors are grateful to David Autor, Caroline Hoxby, Christopher Jencks, Thomas Kane, Lawrence Katz, and participants in the Harvard Labor Economics Seminar for helpful comments.

RICHARD J. MURNANE is Thompson Professor of Education and Society at the Harvard Graduate School of Education, and a Research Associate at the National Bureau of Economic Research.

Table 8. Construction of the analytic sample.

Decision Rule	Number of cases not meeting the criterion	Number of cases left in analytic samples	Number of Males left	Number of Females left
Member of baseline survey (1972)		22,652		
Sex reported consistently	123	22,529	11,273	11,256
Member of 5th follow-up survey (1986)	9,754	12,775	6,078	6,697
1985 earnings data reported	1,068	11,707	5,617	6,090
1985 earnings not equal to zero	1,746	9,961	5,205	4,756
1985 earnings in 1990 $ >= $1000	138	9,823	5,191	4,632
1985 earnings =$99,993 [a]	31	9,792	5,165	4,627
Individual is not a farmer or unpaid farm worker	22	9,770	5,149	4,621
Graduated from high school	11	9,759	5,143	4,616
High school senior math score is not missing	2,807	6,952	3,672	3,280
Race/ethnicity is black, Hispanic, or non-Hispanic White	49	6,903	3,646	3,257
Number of siblings as of 1972 is reported	2	6,901	3,645	3,256

[a] While the codebook is not completely clear, it appears that 99,993 is not a legitimate value for 1985 earnings.

JOHN B. WILLETT is Professor at the Harvard Graduate School of Education.

YVES DUHALDEBORDE is Associate Project Director, International Survey Research, London, England.

JOHN H. TYLER is Assistant Professor, Department of Education, Brown University.

Table 9. Construction of the HS&B analytic samples.

Decision Rule	Number of cases not meeting the criterion	Number of cases left in analytic samples	Number of males left	Number of females left
Member of baseline survey (1982)		14,825		
Educational attainment reported consistently	1,083	13,742	6,714	7,028
Member of 4th follow-up survey (1992)	1,524	12,218	5,880	6,338
1991 earnings data reported	925	11,293	5,556	5,737
1991 earnings not equal to zero	1,095	10,198	5,267	4,931
1991 earnings in 1990 $ >= $1000	138	10,060	5,235	4,825
1991 earnings consistent with other survey information[a]	46	10,014	5,213	4,801
Individual is not a farmer or unpaid farm worker	30	9,984	5,185	4,799
Graduated from high school	1,193	8,791	4,449	4,342
High school senior math score is not missing	805	7,986	4,036	3,950
High school senior reading score is not missing	26	7,960	4,022	3,988
Race/ethnicity is black, Hispanic, or non-Hispanic white	388	7,572	3,822	3,750
Information on postsecondary education present	45	7,527	3,798	3,729

[a] There were 45 cases for which the earnings data seemed inconsistent with other information provided in the 1992 survey.

REFERENCES

Altonji, J.G., & Pierret, C.R. (1996, January). Employer learning and the signaling value of education. National Bureau of Economic Research Working Paper 5438.

Blackburn, McKinley L., & Neumark, D. (1993). Omitted-ability bias and the increase in the return to schooling, Journal of Labor Economics, 11(3), 521–544.

Bowles, S., & Gintis, H. (1998, April). The determinants of individual earnings: Cognitive skills, personality, and schooling. Department of Economics, University of Massachusetts Working Paper.

Bureau of the Census (1997). Statistical abstract of the United States 1997. Washington, DC: U.S. Department of Commerce.

Cawley, J., Heckman, J., & Vytlacil, E. (1998, January). Cognitive ability and the rising return to education. National Bureau of Economic Research Working Paper 6388.

College Entrance Examination Board (1977). On further examination: report of the Advisory Panel on the Scholastic Aptitude Test Score Decline. New York: College Board.

Farber, H.S., & Gibbons, R. (1996, November). Learning and wage dynamics. Quarterly Journal of Economics, 1007–1047.

Gottschalk, P. (1997). Inequality, income growth, and mobility: the basic facts. Journal of Economic Perspectives, 11(2), 21–40.

Heckman, J.J. (1999, Spring). Doing it right: Job training and education. The Public Interest, 135, 86–107.

Howell, D.R. (1994, Summer). The skills myth. The American Prospect, 81–90.

Howell, D.R., & Wolff, E.N. (1991). Trends in the growth and distribution of skills in the U.S. workforce, 1960–1985. Industrial and Labor Relations Review, 44(3), 486—502.

Jencks, C. (1979). Who gets ahead? The determinants of economic success in America. New York: Basic Books.

Jencks, C., & Phillips, M.J. (Eds.) (1998). The black-white test score gap. Washington, DC: Brookings Institution.

Johnson, W.R., & Neal, D. (1998). Basic skills and the black-white earnings gap. In Christopher Jencks & Meredith Jane Phillips (Eds.), The black-white test score gap. Washington, DC: Brookings Institution.

Kane, T.J. (1998, May). Are college students credit-constrained? Kennedy School of Government Working Paper.

Kane, T.J., Rouse, C.E., & Staiger, D.(1999). Estimating returns to schooling when schooling is misreported. National Bureau of Economic Research Working Paper No. 7235.

Katz, L.F., & Autor, D.H. (1999). Changes in the wage structure and earnings inequality. In O. Ashenfelter, D. Card (Eds.) Handbook of labor economics. New York: Elsevier Science Ltd.

Katz, L.F., & Murphy, K.M. (1992). Changes in relative wages: 1963-1987: Supply and demand factors. Quarterly Journal of Economics, 107, 35–78.

Korenman, S., & Winship, C. (1995). A reanalysis of the bell curve: Intelligence, family background, and schooling. NBER Working Paper 5230.

Koretz, D.M. (1987). Educational achievement: explanations and implications of recent trends. Washington, DC: Congressional Budget Office.

Levin, H.M. (1998). Educational performance standards and the economy. Educational Researcher, 27(4), 4–11.

Levy, F., & Murnane, R.J. (1992, September). U.S. Earnings levels and earnings inequality: a review of recent trends and proposed explanations. Journal of Economic Literature, 30, 1333–1381.

Marshall, R., & Tucker, M.S. (1993). Thinking for a living: education and the wealth of nations. New York: Basic Books.

Mishel, L., & Bernstein, J. (1994). The state of working America 1994–95, Economic Policy Institute series. Armonk, NY: M.E. Sharpe.

Mullis, Ina V.S. et al. (1994). NAEP 1992 trends in academic progress: Achievement of U.S. students in science, 1969 to 1992 – mathematics, 1973 to 1992 – reading, 1971 to 1992, prepared by the Educational Testing Service for the National Center for Education Statistics, Office of Educational Research and Improvement. Washington, DC: U.S. Deparment of Education.

Murnane, R.J., & Levy, F. (1996). Teaching the new basic skills. New York: Free Press.

Murnane, R.J., Willett, J.B., & Levy, F. (1995, May). The growing importance of cognitive skills in wage determination. Review of Economics and Statistics, 77, 251–266.

Murphy, K., & Welch, F. (1990). Empirical age-earnings profiles. Journal of Labor Economics, 8(2), 202–229.

National Center for Education Statistics (1996). Digest of education statistics 1996. Washington, DC: U.S. Department of Education.

Rock, D.A., Hilton, T.L., Pollack, J., Ekstrom, R.B., & Goertz, M.E. (1985). Psychometric analysis of the NLS and the high school and beyond test batteries. Washington, DC: National Center for Education Statistics.

Tucker, M.S., & Codding, J.B. (1998). Standards for our schools: How to set them, measure them, and reach them. San Francisco: Jossey-Bass.

Winship, C., & Korenman, S. (1997). Does staying in school make you smarter? In B. Devlin, S.E. Fienberg, D.P. Resnick, & K. Roeder (Eds.), Intelligence, genes, and success: Scientists respond to the bell curve (Ch. 10, pp. 215–234). New York: Springer Verlag.