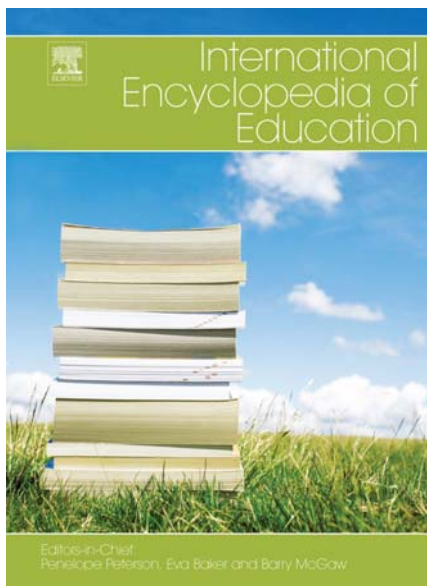


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Education and Economic Growth

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Education has long been viewed as an important determinant of economic well-being. The theoretical growth literature emphasizes at least three mechanisms through which education may affect economic growth. First, education can increase the human capital inherent in the labor force, which increases labor productivity and thus transitional growth toward a higher equilibrium level of output (as in augmented neoclassical growth theories, cf. [Mankiw *et al.* \(1992\)](#)). Second, education can increase the innovative capacity of the economy, and the new knowledge on new technologies, products, and processes promotes growth (as in theories of endogenous growth, cf., e.g., [Lucas \(1988\)](#), [Romer \(1990\)](#), [Aghion and Howitt \(1998\)](#)). Third, education can facilitate the diffusion and transmission of knowledge needed to understand and process new information and to successfully implement new technologies devised by others, which again promotes economic growth (cf., e.g., [Nelson and Phelps, 1966](#); [Benhabib and Spiegel, 1994](#)).

Despite these theoretical predictions, the empirical evidence on the impact of education on economic growth has long been mixed. In large part, this seems to reflect measurement problems. Most people would acknowledge that a year of schooling does not produce the same cognitive skills everywhere. They would also agree that families and peers contribute to education. Health and nutrition further impact cognitive skills. Yet, until recently, research on the economic impact of education – largely due to expedience – has almost uniformly ignored these aspects. Recent research shows that ignoring differences in the quality of education significantly distorts the picture of how educational and economic outcomes are related.

Early Studies of Schooling Quantity and Economic Growth

The majority of the macroeconomic literature on economic returns to education employs measures of the quantity of schooling. The most common measure is years of schooling, averaged across the working-age population. ([Woessmann \(2003\)](#) surveys issues of measuring and specifying human capital from early growth accounting to current cross-country growth regressions.) The standard method of estimating the effect of education on economic growth is to estimate cross-country growth regressions where average annual growth in gross domestic product

(GDP) per capita over several decades is expressed as a function of measures of schooling and a set of other variables deemed important for economic growth.

Following the classical contributions by [Barro \(1991, 1997\)](#) and [Mankiw *et al.* \(1992\)](#), a vast early literature of cross-country growth regressions tended to find a significant positive association between quantitative measures of schooling and economic growth. Extensive reviews of the literature are found in [Topel \(1999\)](#), [Temple \(2001\)](#), [Krueger and Lindahl \(2001\)](#), and [Sianesi and Van Reenen \(2003\)](#). To provide an idea of the robustness of the basic association, primary schooling turns out to be the most robust influence factor (after an East Asian dummy) on growth in GDP per capita in 1960–1996 in the extensive robustness analysis of 67 explanatory variables in growth regressions on a sample of 88 countries by [Sala-i-Martin *et al.* \(2004\)](#).

Figure 1 provides a basic representation of the association between years of schooling and economic growth on the most recent version of available data. This research suggests that each year of schooling is associated with long-run growth that is 0.58 percentage points higher.

Yet, questions persist about the interpretation of such relationships. A substantial controversy addresses whether it is the level of years of schooling (as would be predicted by several models of endogenous growth) or the change in years of schooling (as would be predicted by basic neoclassical models) that is the more important driver of economic growth (e.g., [Krueger and Lindahl, 2001](#)). It seems beyond the scope of current data to draw strong conclusions about the relative importance of different mechanisms for schooling quantity to affect economic growth. Even so, several recent studies suggest that education is important both as an investment in human capital and in facilitating research and development and the diffusion of technologies, with initial phases of education more important for imitation and higher education for innovation ([Vandenbussche *et al.*, 2006](#)).

Two more skeptical studies raise caveats. [Bils and Klenow \(2000\)](#) raise the issue of causality, suggesting that reverse causation running from higher economic growth to additional education may be at least as important as the causal effect of education on growth in the cross-country association. [Pritchett \(2001, 2006\)](#) raises questions about the plausibility of simple growth models with years of schooling and stresses that it is important for economic growth to get other things right as well,

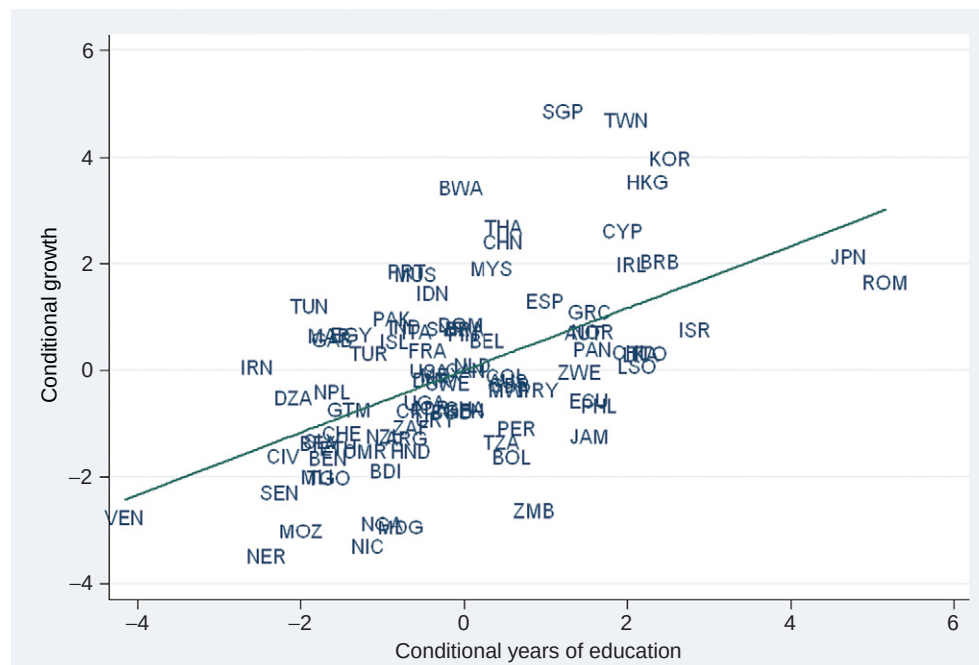


Figure 1 Association between years of schooling and long-run economic growth. Added-variable plot of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960–2000 on average years of schooling in 1960 and the initial level of real GDP per capita in 1960.

in particular the institutional framework of the economy. Both issues are discussed further below.

However, most importantly, using average years of schooling as an education measure implicitly assumes that a year of schooling delivers the same increase in knowledge and skills regardless of the education system. This measure also assumes that formal schooling is the primary source of education and that variations in the quality of nonschool factors affecting learning have a negligible effect on education outcomes. This neglect of cross-country differences in the quality of education is the major drawback of such a quantitative measure.

Initial Evidence on the Quality of Education and Economic Growth

Quite clearly, the average student in Ghana or Peru does not gain the same amount of knowledge in any year of schooling as the average student in Finland or Korea; however, using measures of years of schooling assumes that they are equivalent. In addition, using years of schooling implicitly assumes that all skills and human capital come from formal schooling. Yet, extensive evidence on knowledge development and cognitive skills indicates that a variety of factors outside of school – family, peers, and others – have a direct and powerful influence. Ignoring these nonschool factors introduces another element of measurement error into the growth analyses.

Since the mid-1960s, international agencies, such as the International Association for the Evaluation of Educational Achievement (IEA) and the Organization for Economic Co-operation and Development (OECD), have conducted many international tests – such as the Trends in International Mathematics and Science Study (TIMSS), the Programme for International Student Assessment (PISA), and their predecessors – of student performance in cognitive skills mathematics, involving science, and other subjects. In order to make performance on a total of 36 international tests from 12 testing occasions comparable, Hanushek and Woessmann (2009) develop a common metric to adjust both the level of test performance and its variation through two data transformations. First, each of the separate international tests is benchmarked to a comparable level by calibrating the US international performance over time to the external standard of the available US longitudinal test (the National Assessment of Educational Progress, NAEP). Second, the dispersion of the tests is standardized by holding the score variance constant within a group of 13 OECD countries with relatively stable secondary school attendance rates over time.

Figure 2 reports average performance at the standardized tests, which serves as a proxy for the quality of education. The variation in the quality of education that exists among OECD countries is already substantial, but the difference from developing countries in the average amount of learning acquired after a given amount of

schooling dwarfs any within-OECD difference. Outside of East Asia, nearly every developing country that participated in one of the tests performed dramatically lower than any OECD country (except Mexico).

Over the past 10 years, growth research demonstrates that considering the quality of education, measured by the cognitive skills learned, dramatically alters the assessment of the role of education in economic development. Using

the data from the international student achievement tests through 1991 to build a measure of educational quality, Hanushek and Kimko (2000) find a statistically and economically significant positive effect of the quality of education on economic growth in 1960–1990 that is far larger than the association between the quantity of schooling and growth. Ignoring quality differences very significantly misses the true importance of education for economic

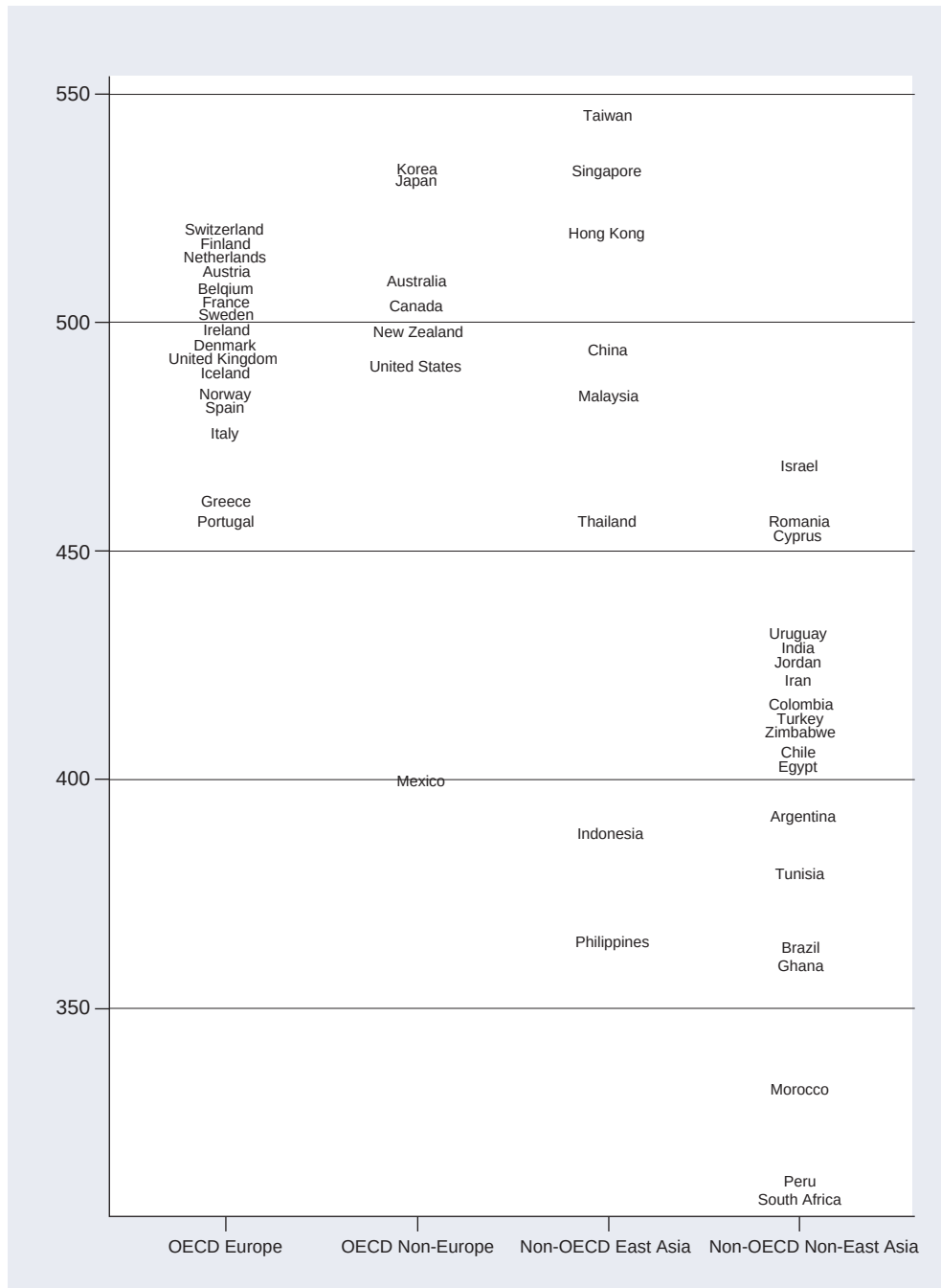


Figure 2 Performance on international student achievement tests. Simple average of the mathematics and science scores over all available international tests, using the rescaled data by Hanushek and Woessmann (2009) that puts performance at different international tests on a common scale.

growth. Their estimate suggest that one country-level standard deviation higher test performance (equivalent to 47-test-score points on the scale used in [Figure 2](#)) would yield about one percentage point higher annual growth.

This estimate stems from a statistical model that relates annual growth rates of real GDP per capita to the measure of educational quality, years of schooling, the initial level of income, and several other control variables (including, in different specifications, the population growth rates, political measures, openness of the economies, and the like). Adding educational quality to a base specification including only initial income and educational quantity boosts the variance in GDP per capita among the 31 countries in Hanushek and Kimko's sample that can be explained by the model from 33% to 73%. The effect of years of schooling is greatly reduced by including quality, leaving it mostly insignificant. At the same time, adding the other factors leaves the effects of cognitive skills basically unchanged.

Several studies have since found very similar results, including [Barro \(2001\)](#), [Woessmann \(2002, 2003\)](#), [Bosworth and Collins \(2003\)](#), [Coulombe and Tremblay \(2006\)](#), and [Jamison *et al.* \(2007\)](#). In sum, the evidence suggests that the quality of education, measured by the knowledge that students gain as depicted in tests of cognitive skills, is substantially more important for economic growth than the mere quantity of schooling.

Recent Evidence on the Importance of Cognitive Skills for Economic Growth

The most recent evidence by [Hanushek and Woessmann \(2008, 2009\)](#) adds international student achievement tests not previously available and uses the most recent data on economic growth to analyze an even longer period (1960–2000). It extends the sample of countries with available test-score and growth information to 50 countries. These data are also used to analyze effects of the distribution of educational quality at the bottom and at the top on economic growth, as well as interactions between educational quality and the institutional infrastructure of an economy.

The measure of the quality of education is a simple average of the mathematics and science scores over international tests, interpreted as a proxy for the average educational performance of the whole labor force. This measure encompasses overall cognitive skills, not just those developed in schools. Thus, whether skills are developed at home, in schools, or elsewhere, they are included in the growth analyses.

After controlling for the initial level of GDP per capita and for years of schooling, the test-score measure features a statistically significant effect on the growth of real GDP per capita in 1960–2000 ([Figure 3](#)). According to this simple specification, test scores that are larger by 1 SD

(measured at the student level across all OECD countries in PISA) are associated with an average annual growth rate in GDP per capita that is two percentage points higher over the whole 40-year period which is almost identical to the prior estimates in Hanushek and Kimko (2000).

Adding educational quality to a model that just includes initial income and years of schooling increases the share of variation in economic growth explained from 25% to 73%. As reported above, the quantity of schooling is statistically significantly related to economic growth in a specification that neglects educational quality, but the association between years of schooling and growth turns insignificant and is reduced to close to zero once the quality of education is included in the model ([Figure 4](#)). In addition, considering the variation just within each of five world regions, educational quality is significantly related to economic growth, indicating that it does not simply reflect economic differences across regions.

Recent literature on the determinants of economic growth emphasizes the importance of the institutional framework of the economy (e.g., [Acemoglu *et al.*, 2001, 2002](#)). The most common and powerful measures of the institutional framework used in empirical work are the openness of the economy to international trade and the security of property rights. These two institutional variables are jointly highly significant when added to the model. However, the positive effect of educational quality on economic growth is very robust to the inclusion of these controls, albeit slightly reduced in magnitude to 1.26 percentage points annual growth per standard deviation of cognitive skills.

Other possible determinants of economic growth often discussed in the literature are fertility and geography. However, when the total fertility rate and common geographical proxies, such as latitude or the fraction of the land area located within the geographic tropics, are added to the model, neither is statistically significantly associated with economic growth.

The results are remarkably similar when comparing the sample of OECD countries to the sample of non-OECD countries, with the point estimate of the effect of educational quality slightly larger in non-OECD countries. When the sample is separated based on whether a country was below or above the median of GDP per capita in 1960, the effect of educational quality is statistically significantly larger in low-income countries than in high-income countries (cf. [Hanushek and Woessmann, 2009](#)).

Among the developing countries, the conclusion is that once there is a high-quality school system, it pays to keep children in school longer – but it does not pay if the school system does not produce skills.

The results are very robust to alternative specifications of the growth relationships. For example, the impact of

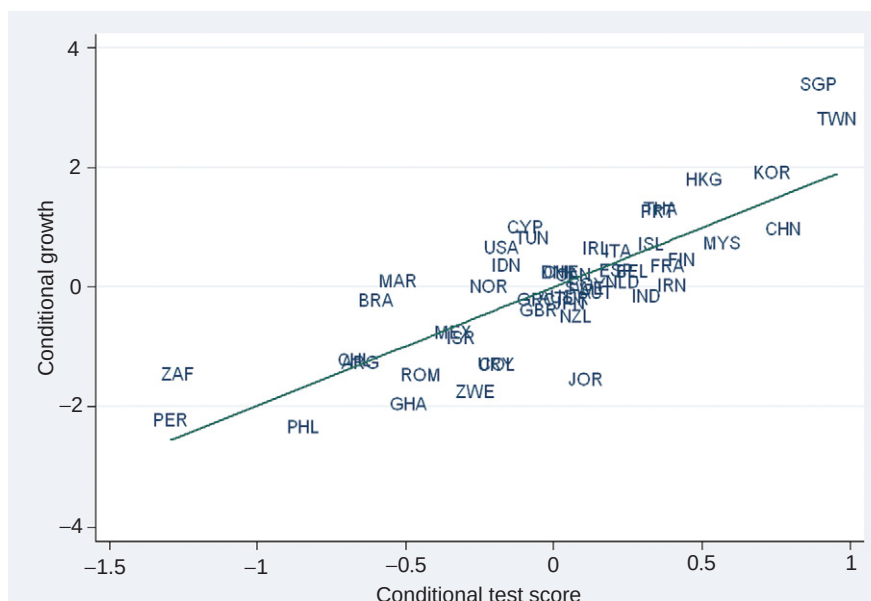


Figure 3 Test scores and long-run economic growth. Added-variable plots of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960–2000 on the initial level of real GDP per capita in 1960, average test scores on international student achievement tests, and average years of schooling in 1960. Calculations from Hanushek, E. A. and Woessmann, L. (2008).

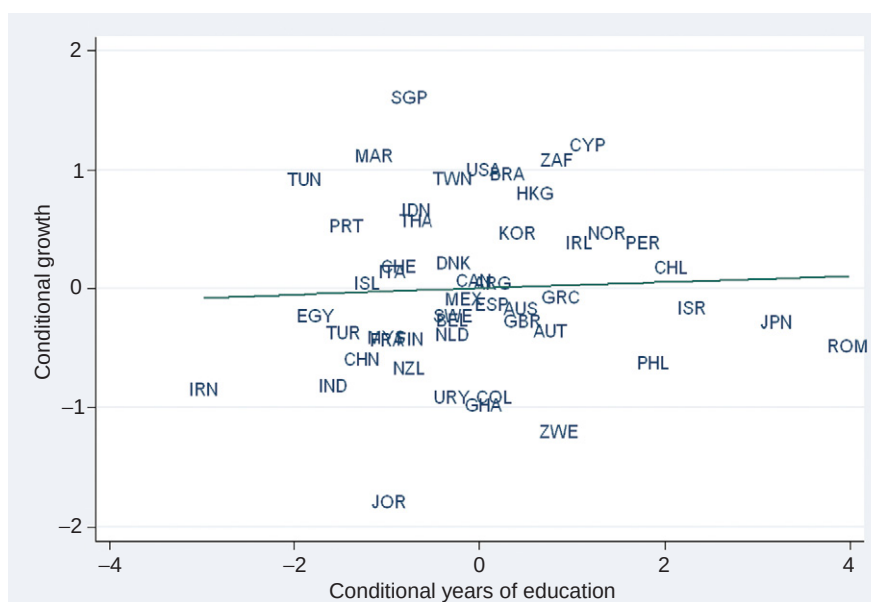


Figure 4 Years of schooling and economic growth after controlling for test scores. Added-variable plots of a regression of the average annual rate of growth (in percent) of real GDP per capita in 1960–2000 on the initial level of real GDP per capita in 1960, average test scores on international student achievement tests, and average years of schooling in 1960. Calculations from Hanushek, E. A. and Woessmann, L. (2008).

cognitive skills remains qualitatively the same when measured just by the tests performed at the level of lower secondary education, which seems the most readily comparable level. The results are also robust to performing the analyses in two subperiods, 1960–1980 and 1980–2000, and to dropping East Asian countries (which have both high levels of cognitive skill and rapidly growing economies).

All in all, the results do not appear to be an artifact of the specific time period, set of countries, or achievement measurement decisions.

Results are also confirmed when looking at whether a country's estimated cognitive skills affect the earnings of immigrants working in the United States. Higher home-country cognitive skills translate into higher earnings

if the immigrants were educated in their homeland, but not if educated in the United States (cf. [Hanushek and Woessmann, 2009](#), for details). By looking at workers on the same labor market, this analysis addresses several issues of endogeneity, excluding the possibility that the results might be driven by other attributes of the countries that affect growth, such as efficient market organizations, which may also be associated with efficient and productive schools.

The Interaction of Educational Quality with Economic Institutions

Economic institutions appear to interact with the effect of educational quality on economic growth. The institutional framework of a country affects the relative profitability of piracy and productive activity. If the available knowledge and skills are used in the former activity rather than the latter, the effect on economic growth may be very different, perhaps even turning negative ([North, 1990](#)). The allocation of talent between rent-seeking and entrepreneurship matters for growth: countries with more engineering students grow faster and countries with more law students grow more slowly ([Murphy *et al.*, 1991](#)). Education may not have much impact in less-developed countries that lack other facilitating factors such as functioning institutions for markets and legal systems ([Easterly, 2001](#)). Besides, due to deficiencies in the institutional environment, cognitive skills might be applied to socially unproductive activities in many developing countries ([Pritchett, 2001](#)).

Adding the interaction of educational quality and one institutional measure – openness to international trade – to the growth specification indicates not only that both have significant individual effects on economic growth but also that there is a significant positive interaction. The effect of educational quality on economic growth is indeed significantly higher in countries that have been fully open to international trade than in countries that have been fully closed. The effect of educational quality on economic growth is significantly positive, albeit relatively low at 0.9 per SD in closed economies but increases to 2.5 per SD in open economies. When using protection against expropriation rather than openness to trade as the measure of institutional quality, there is similarly a positive interaction term with educational quality, although it lacks statistical significance.

In sum, both the quality of the institutional environment and the quality of education seem important for economic development. Furthermore, the effect of educational quality on growth seems significantly larger in countries with a productive institutional framework, so that good institutional quality and good educational quality can reinforce each other. Thus, the macroeconomic

effect of education depends on other complementary growth-enhancing policies and institutions. However, cognitive skills have a significant positive growth effect even in countries with a poor institutional environment.

Finally one issue related to institutions remains unresolved, [Glaeser *et al.* \(2004\)](#) suggests that human capital may itself lead to better institutions: as, such, the estimates of cognitive skills without consideration of economic institutions would be appropriate.

Simulating the Impact of Educational Reform on Economic Growth

It is important to understand the implications of policies designed to improve educational outcomes. The previous estimates provide information about the long-run economic implications of improvements in educational quality. For a better understanding of the impact of improved achievement, it is useful to relate policy reforms directly to the pattern of economic outcomes consistent with feasible improvements.

As a benchmark, consider a reform that yields a 0.5 standard deviation (SD) improvement in average achievement of school completers. We can put this metric in the context of the previous estimates. Consider, for example, a developing country – such as Brazil, Indonesia, Mexico, or Thailand in PISA 2003 – with average performance at roughly 400 test-score points, approximately minimal literacy. An aggressive reform plan would be to close half the gap with the average OECD student, an improvement of one half SD. Alternatively, consider what it would mean if a country currently performing near the mean of OECD countries in PISA at 500 test-score points (e.g., Norway or the United States in PISA 2000, or Germany in PISA 2003) managed to increase its educational quality to the level of top performers in PISA at roughly 540 test-score points (e.g., Finland or Korea). Such an increase amounts to 0.4 SD.

The timing of the reform is also important in two ways. First, such movement of student performance cannot be achieved instantaneously but requires changes in schools that will be accomplished over time (say, through systematic replacement of teachers through retirement and subsequent hiring). The time frame of any reform is difficult to specify, but achieving the change of 0.5 standard deviation (SD) described above for an entire nation may take 20–30 years. Second, if the reforms succeed, their impact on the economy will not be immediate – initially the new graduates will be a small part of the labor force. It will be some time after the reform of the schools before the impact on the economy is realized. In other words, the prior estimates are best thought of as the long-run, or equilibrium, outcomes of a labor force with a given educational quality.

Faster reforms will have larger impacts on the economy, simply because the better workers become a dominant part of the workforce sooner ([Figure 5](#)). However, even a 20- or 30-year reform plan begun in 2005 has a powerful impact. For example, a 20-year plan would yield a GDP 5% greater in 2037 (compared with an economy with no increase in educational quality). The figure also plots 3.5% of GDP, an aggressive spending level for education in many countries of the world. A growth dividend of 5% of GDP would more than cover all primary and secondary school spending. But even a 30-year reform program (not fully accomplished until 2035) would still yield more than 5% higher real GDP by 2041.

Projecting these net gains from improved educational quality further past the reform period vividly shows the long-run impacts of reform. Over a 75-year horizon, a 20-year reform yields a real GDP 36% higher than without a change in educational quality.

It must nonetheless be clear that these effects represent the result from actual gains in educational outcomes. There have been many attempts around the world to improve student outcomes, and many of these have failed to yield gains in student performance. Bad reforms – those without impacts on students – will not have these growth effects.

This simulation shows that the previous estimates of the effects of educational quality on growth have large impacts on national economies. At the same time, while the rewards are large, they also imply that policies must be considered across long periods, requiring patience – patience that is not always clear in national policymaking. These reforms must also be put in a broader perspective

because other kinds of institutional changes and investments will also take time. Changing basic economic institutions, for example, seldom happens overnight, and the economy needs time to adjust.

Summary

The accumulated evidence from analyses of economic outcomes is that the quality of education – measured on an outcome basis of cognitive skills – has powerful economic effects. Economic growth is strongly affected by the skills of workers. What people know matters.

This message is important in developed and developing countries alike. In the latter, much of the discussion of development policy today simplifies and distorts this message. It recognizes that education matters, but focuses most attention on ensuring that everybody is in school – regardless of the learning that goes on. As a recent report by the [World Bank Independent Evaluation Group \(2006\)](#) documents, high priority was accorded to increasing primary school enrolment in developing countries over the past 15 years. Whether children were learning garnered much less attention. International testing indicates that, even among those attaining lower secondary schooling, literacy rates (by international standards) are very low in many developing countries. By reasonable calculations, many countries have fewer than 10% of their youth currently reaching minimal literacy and numeracy levels, even when school attainment data look considerably better (cf. [Hanushek and Woessmann \(2008\)](#) for details).

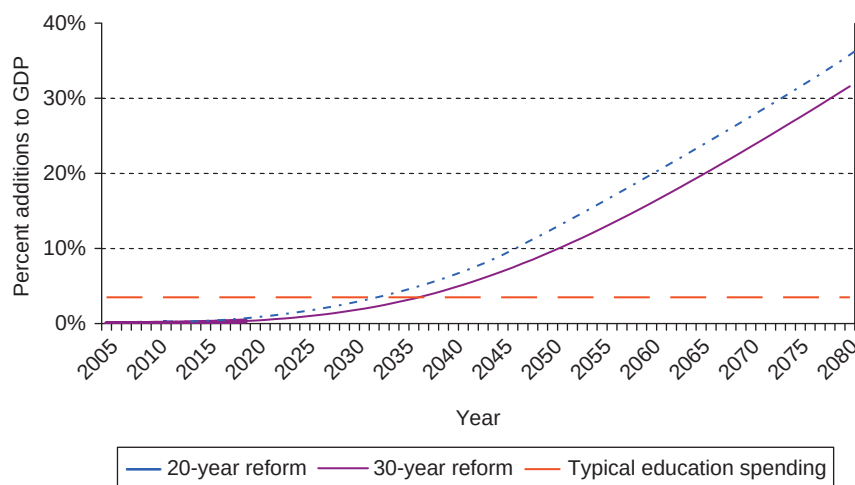


Figure 5 Simulation of the impact on GDP of moderately strong knowledge improvement. Simulation of the impact on the economy of reform policies beginning in 2005 and taking 20 or 30 years for a 0.5 SD improvement in student outcomes at the end of upper secondary schooling. The figure indicates how much larger the level of GDP is at any point after the reform policy is begun as compared to that with no reform; that is, the estimates suggest the increase in GDP expected over and above any growth from other factors. The figure also plots 3.5% of GDP, an aggressive spending level for education in many countries of the world. Even a 30-year reform program would yield a growth dividend covering the whole of this spending level by 2036. See [Hanushek and Woessmann \(2007\)](#) for details. From Hanushek, E. A. and Woessmann, L. (2007). The role of school improvement for economic development. *NBER Working Paper 12832*. Cambridge, MA: National Bureau of Economic Research.

Because of the reported findings – that knowledge rather than just time in school is what counts for economic growth – policies must pay more attention to the quality of schools.

See also: Education and Inequality; Returns to Education in Developed Countries; Returns to Education in Developing Countries; School Quality and Earnings; The External Benefits of Education.

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