



Skills-adjusted human capital shows rising global gap

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Human capital, broadly defined as the skills acquired through formal education, is acknowledged as one of the key drivers of economic growth and social development. However, its measurement for the working-age populations, on a global scale and over time, is still unsatisfactory. Most indicators either only consider the quantity dimension of education and disregard the actual skills or are demographically inconsistent by applying the skills of the young cohorts in school to represent the skills of the working-age population at the same time. In the case of rapidly expanding or changing school systems, this assumption is untenable. However, an increasing number of countries have started to assess the literacy skills of their adult populations by age and sex directly. Drawing on this literacy data, and by using demographic backprojection and statistical estimation techniques, we here present a demographically consistent indicator for adult literacy skills, the skills in literacy adjusted mean years of schooling (SLAMYS). The measure is given for the population aged 20 to 64 in 185 countries and for the period 1970 to 2015. Compared to the conventional mean years of schooling (MYS)—which has strongly increased for most countries over the past decades, and in particular among poor countries—the trends in SLAMYS exhibit a widening global skills gap between low- and high-performing countries.

human capital indicator | literacy skills | education | cross-country analysis | demography

Since antiquity, education has been considered one of the most important investments into young people aside from health. From Confucius and Socrates to modern enlightenment and up to the recent Sustainable Development Goals, the enhancement of the skills of the young generations has been an almost universal aspiration of human civilization. However, access to learning opportunities was limited to small elites, and only from the 19th century onward has it been gradually spreading to all men and subsequently women, first in Northern Europe and over the 20th century in most countries (1).

To describe the relevance of education for the individual life and for national prosperity, researchers have developed the concept of human capital. In a narrow economic sense, the term refers to the level of skills embodied in an individual that could be used to generate earnings in the labor market (2–4). A broader definition includes health and general cognitive empowerment (5, 6), and looks at benefits far beyond monetary returns, ranging from demographic trends (7, 8), to criminality (9), quality of institutions, and social cohesion (10).

To comprehensively assess the multiple benefits of investments in education, large globally comparable sets of data are required (11–13). So far, global indicators of adult human capital estimated at the country level and over time include mean years of schooling (MYS) (14–16) and full educational attainment distributions disaggregated by age and sex (17–21). Attempts to address the quality of education in addition to or instead of the quantity mostly use international school assessment data (22–25). While human capital theory clearly focuses on the benefits of adult skills, so far global harmonized datasets on education quality have

focused on the school-age population (26, 27), despite the fact that the skills assessed in schools were found to be a poor measure of the concurrent level of adult skills in a population (28).

To fill this important gap in global human capital data, we present an indicator, the skills in literacy adjusted mean years of schooling (SLAMYS). This indicator improves on currently available human capital indicators in four dimensions: 1) reliance on adult skills surveys; 2) demographic consistency; 3) global availability; and 4) temporal evolution since 1970. By introducing SLAMYS, we not only provide insights in the evolution of inequality in adult skills between countries and over time, but also present researchers with a consistent global dataset for further studies on the relationship between human capital and development outcomes.

Our empirical exercise relies on data harmonization, demographic modeling, and statistical estimation for 185 countries. Empirical adult literacy skills assessment scores came from four different survey types: International Adult Literacy Survey (IALS) (29), Program for the International Assessment of Adult Competencies (PIAAC) (30), Skills toward Employment and Productivity Survey (STEP) (31), and Demographic and Health Survey (DHS) (32). Existing estimates of educational attainment distributions and resulting MYS by age and sex for all countries for 1970 to 2015 were collected from the Wittgenstein Centre (WIC) Human Capital Data Explorer (20). For countries without direct empirical evidence on adult literacy skills, the statistical estimation model included among others, adult literacy, school enrolment rates, educational expenditure, and pupil–teacher

Significance

After a rapid expansion of primary school enrollment rates in many developing countries starting around 2000, progress toward development goals was widely acknowledged. However, the comprehensive focus on tested literacy skills presented in this paper shows that, in many countries, this expansion in quantity came at the expense of quality. Given the overriding importance of skilled human capital in modern knowledge societies, this is a worrisome trend with the possible negative implications of the current COVID-19 crisis on schooling possibly exacerbating the situation.

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ratios from the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute of Statistics (33), and harmonized learning scores from the Global Dataset on Education Quality (34). The specific data and methods applied are described in detail in *SI Appendix*.

The Demography of Educational Attainment and Skill Changes over the Life Course

In nearly all societies, the transmission of skills starts at very young ages and takes different forms through the stages of child development. This child-centered system of education is based on the highest plasticity of brain functioning at young age (35). In modern societies, formal education in schools starts at ages 5 to 7, and typically ends before age 25, with only some postgraduate education thereafter. The highest level of formal educational attainment rarely changes over the life course afterward. On the other hand, when it comes to the stock of skills and knowledge that individuals possess at certain ages, research has shown that it can increase or decline with age (36).

The prevalence of adult skills in a population at a given time therefore reflects a rather complex interplay of several factors, in particular age and cohort effects. When school participation rates and the length of schooling change over time, as they have recently in virtually all countries, the educational attainment distribution by age portrays the history of educational expansion.

Consider the case of Singapore, for which the educational distribution of the population by age and sex in 2015 is displayed in Fig. 1. More than 80% of men and women aged 25 to 29 have some postsecondary or higher education (dark blue area), which is the highest attainment of young cohorts in the world today, rivalled only by South Korea. At the same time, over a third of women aged 60 to 64 in Singapore have only primary education or never attended any schools (dark red area), which is a result of a cohort effect: The cohort of women aged 60 to 64 in 2015 were 5 to 9 y old in 1960 when Singapore did not have universal primary education because it was still a poor developing country. Hence, under conditions of rapidly expanding school systems, the human capital indicators averaging over the entire adult population provide a poor measure by combining education outcomes of highly educated young cohorts with poorly educated older ones. It is also misleading when researchers use the

average education of the youngest cohorts as a proxy for the human capital of the entire adult population in the analysis of the economic returns to education (25). The explicit consideration of age-cohort-specific human capital in economic growth regressions helped to resolve past ambiguities (11). In the context of Singapore, its economy displayed the fastest rates of economic growth when the better-educated young cohorts entered the working ages (37).

Here, we present a way to estimate the quality/literacy skills dimension of human capital, while still maintaining the advantages of cohort-specific analysis. For this, we use PIAAC literacy skills data disaggregated by age, sex, and educational attainment categories. Fig. 1 shows the skills-adjusted educational attainment distribution depending on whether the age–sex–education group is above (filled) or below (striped) the Organisation for Economic Co-operation and Development (OECD)-average literacy skill level of that group. While for the youngest cohorts skills of most people are above the OECD average, for age groups above age 30 the filled areas for all education categories cover less than half of the bars, indicating that literacy skills in Singapore for older cohorts are still predominantly below the OECD average. This implies that while the quantity of education increased rapidly the quality of education improved even faster than the OECD average.

To construct our dataset of SLAMYS, it was necessary to also make assumptions concerning the changes of literacy skills with age. Whereas for backward projections of highest educational attainment distributions only assumptions on differential mortality and migration are required, for the equivalent reconstruction of the literacy skills of the population along cohort lines, the situation is more complex because skills can further increase or decline with age. Fig. 2 compares average literacy test scores from the 1994–1998 IALS and 2011–2017 PIAAC surveys, which use comparable tests for the same cohorts, who were of different ages at the time of the surveys. As expected (36, 38), there is heterogeneity in the pattern of changes with age according to education groups, which reflects the different exposure to cognitive stimulation over their life course. As the figure displays, individuals who completed upper secondary or higher education have, on average, considerably higher test scores in both surveys and an age-pattern of skills different from

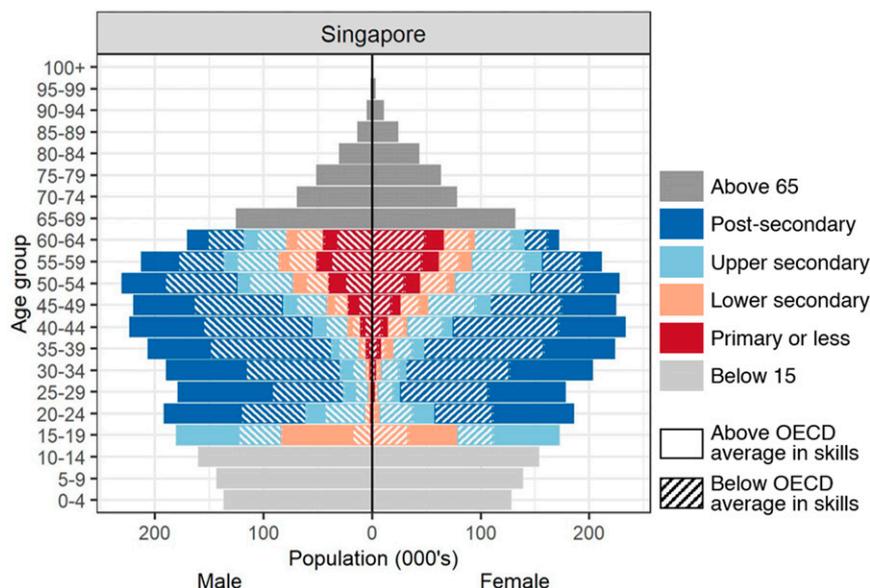


Fig. 1. Age and education pyramid of Singapore 2015 with skills levels at each attainment category being classified as being above (filled) or below (striped) OECD average. Calculations are based on data from the PIAAC Survey of Adult Skills (30) and the WIC Human Capital Data Explorer (20).

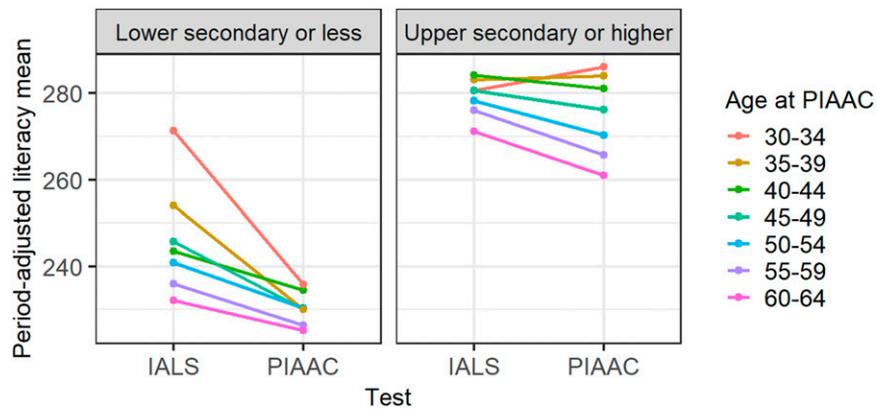


Fig. 2. Changes of skills with age for different age and education groups resulting from a comparison between IALS 1994–1998 (29) and PIAAC 2011–2017 (30) for 16 countries.

other educational categories. Highly educated individuals experience modest gains in literacy skills until the age of 40 when a modest decline starts. In contrast, low-educated individuals face the most dramatic decrease in literacy skills up to age 40, followed by a more moderate decline thereafter. It may be plausible that this pattern is the result of lower skill demand after individuals leave school: While better educated individuals gain some further literacy skills in the work environment, low-educated individuals do not use their formal skills sufficiently, and thus rapidly lose them soon after leaving school. This differential age effect on literacy skills development over the life course is also taken into account when reconstructing the full set of skills-adjusted human capital for men and women along cohort lines from 2015 back to 1970 as described in detail in *SI Appendix*.

Cross-Country and over Time Trends in MYS and SLAMYS

Our method to develop a skills in literacy adjusted human capital indicator, SLAMYS, resulted in a unique dataset of the skills of the working-age population for 185 countries for the period 1970 to 2015. We present here results for selected countries as well as a comparison between trends in SLAMYS and a traditional measure of educational attainment—the MYS, which were drawn from the WIC Human Capital Data Explorer (20). Table 1 presents these indicators for all world regions and selected large countries over 45 y. Data for 185 countries and for quinquennial time intervals are provided in *SI Appendix*.*

At the global level, MYS of the working-age population increased from 4.81 in 1970 to 8.53 in 2015. This is an impressive increase in average educational attainment of the world population, particularly considering that, over the same period, world population also increased from 3.7 to 7.4 billion (39), making school expansion an uphill battle. The respective global improvement in the skills in literacy adjusted human capital, SLAMYS, was from 3.73 y in 1970 to 6.88 y in 2015. Although the absolute difference was smaller for SLAMYS, the relative difference was higher (84 versus 77% increase).

These global average trends hide considerable regional and national differences. In terms of SLAMYS, Eastern Asia displayed the largest increase over time: from 3.16 SLAMYS in 1970 to 8.35 in 2015. On the other hand, sub-Saharan Africa observed an increase from the extremely low level of 0.79

SLAMYS in 1970 to 3.19 in 2015. That means that, currently, sub-Saharan Africa has about the same SLAMYS level as Eastern Asia in 1970. If skills are indeed a key driver of social and economic development, this result implies that sub-Saharan Africa lags almost half a century behind Eastern Asia. For other

Table 1. MYS and SLAMYS of selected regions and countries

Regions and countries	MYS		MYS diff.	SLAMYS		SLAMYS diff.
	1970	2015		1970	2015	
World	4.81	8.53	3.72	3.73	6.88	3.15
Oceania	9.63	13.31	3.68	9.74	14.04	4.30
Northern America	10.68	12.93	2.25	10.32	13.33	3.01
Europe	8.15	12.07	3.92	7.81	12.26	4.45
Eastern Asia	4.53	9.29	4.76	3.16	8.35	5.19
Latin America	4.26	8.71	4.45	2.91	6.84	3.93
MENA	2.69	8.08	5.39	1.65	5.77	4.12
Central and South Asia	2.89	7.32	4.43	1.48	4.92	3.44
Sub-Saharan Africa	1.84	5.91	4.07	0.79	3.19	2.40
Japan	10.68	13.81	3.13	11.09	15.59	4.50
Australia	10.03	13.68	3.65	10.52	14.67	4.15
New Zealand	9.75	13.52	3.77	9.10	14.48	5.38
Finland	8.85	13.03	4.18	8.71	14.27	5.56
Switzerland	10.93	13.40	2.47	11.72	14.14	2.42
Germany	11.94	13.73	1.79	11.41	14.09	2.68
United Kingdom	10.90	13.26	2.36	11.63	13.81	2.18
South Korea	6.02	12.90	6.88	5.57	13.31	7.74
United States	10.69	12.89	2.20	10.34	13.27	2.93
Singapore	4.90	12.64	7.74	3.58	12.28	8.70
Malaysia	3.80	11.61	7.81	2.17	10.12	7.95
Zimbabwe	4.14	10.96	6.82	2.23	8.36	6.13
Saudi Arabia	2.27	10.20	7.93	0.96	8.26	7.30
China	3.61	8.64	5.03	1.98	7.35	5.37
Indonesia	3.63	9.06	5.43	1.99	7.03	5.04
Algeria	1.86	9.70	7.84	0.66	6.48	5.82
Brazil	3.38	7.49	4.11	2.03	5.70	3.67
India	2.43	6.94	4.51	0.95	4.35	3.40
Kenya	2.51	8.28	5.77	0.78	3.61	2.83
Nigeria	1.38	6.75	5.37	0.45	3.28	2.83
Ghana	3.13	7.58	4.45	1.16	2.31	1.15
Burkina Faso	0.26	2.58	2.32	0.07	0.63	0.56
Mali	0.37	2.25	1.88	0.10	0.57	0.47
Niger	0.14	1.95	1.81	0.04	0.56	0.52

MYS, mean years of schooling; SLAMYS, skills in literacy adjusted mean years of schooling.

*Countries were selected based on availability of educational attainment data drawn from the WIC Human Capital Data Explorer. The 185 countries in our sample represent 99.2% of the world's population in 2015.

major world regions, Latin America in 1970 was only somewhat behind Eastern Asia, but over time has fallen further back. The same is true for Central and South Asia, which displayed an even slower progress than that observed for Latin America, and today has the second lowest SLAMYS after sub-Saharan Africa. Among the industrialized countries, Europe (East and West together) has been catching up with North America, which had a clear advantage in 1970. Recently, Oceania surpassed North America.

A closer look at country-specific trends reveals interesting and unique pathways. Some countries with high levels of SLAMYS in 1970 displayed a remarkable increase over time, even more than the observed rate for the conventional MYS. Japan in 1970 in terms of SLAMYS was fifth after Switzerland, Latvia, United Kingdom, and Germany, and made it to the top of the list with 15.59 SLAMYS in 2015, a performance considerably better than the United States, with 13.27 SLAMYS in 2015. Finland also showed a formidable increase from being only 17th in Europe in 1970 to the highest level of SLAMYS in Europe in 2015. Outside of Europe, South Korea had a very impressive rate of increase in SLAMYS, starting from only 5.57 in 1970 and having surpassed the United States with 13.31 in 2015.

On the other end of the spectrum, many countries in Africa and South Asia were making rather good progress in terms of the conventional MYS, but much less so when considering SLAMYS. For Ghana, for instance, MYS more than doubled from 3.13 to 7.58 between 1970 and 2015, but SLAMYS increased only marginally from 1.16 to 2.31. Africa's most populous country, Nigeria, showed a similar pattern: MYS increased very impressively by a factor of almost five from 1.38 to 6.75 (more than South Korea in 1970); however, SLAMYS for Nigeria only increased from a very low 0.45 in 1970 to 3.28, which equals roughly the current African-continent average. Kenya shows a similar pattern: Formal schooling rates expanded very rapidly over the past decades, but the measured skills could not keep pace with this expansion. Nevertheless, there is also significant heterogeneity across Africa. Niger stays with little improvement at the bottom level, with 1.95 MYS and a mere 0.56 SLAMYS in 2015. On the other hand, Zimbabwe has shown significant gains in SLAMYS, which increased by almost a factor of four (from 2.23 in 1970 to 8.36 in 2015), reaching the same level of skills as the average of Eastern Asia today. The evidence for Zimbabwe again illustrates the momentum of increases in human capital of the working-age population, as the country still benefits from its previously excellent school system, which prevailed before the conflicts and related challenges (40).

This study challenges the view that the partly impressive recent gains in the expansion of schooling in many developing countries lead to a corresponding increase in human capital. When considering the estimated skills of the working-age population rather than school enrolment rates, the picture looks less impressive. Fig. 3 depicts the differences between quartiles of the distribution of MYS and SLAMYS for all countries ranked by their average level over 1970 to 2015 and grouped into quartiles accordingly. The picture shows the change over time in the difference between the mean of the countries above the highest quartile and the mean of the countries below the lowest quartile. For MYS, this difference peaked around 1990 to 1995 and has since declined because some of the countries with very low education levels have made progress in terms of expanding formal education. However, the trend over time in SLAMYS shows no such reversal. The gap between highly skilled and low skilled populations is widening and has increased to the equivalent of over 10 y of schooling.

This widening global gap in the literacy skills of the working-age population will have significant implications for disparities among countries in their economic development, health, and well-being, particularly in the current transition to knowledge societies and the digital revolution. Given the great relevance of

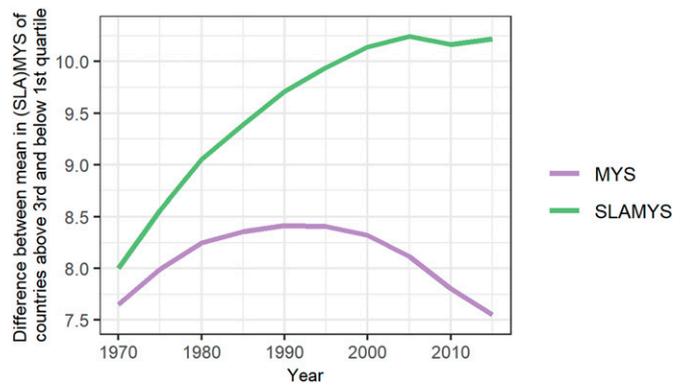


Fig. 3. Difference between the mean of countries above the third quartile and the mean of countries below the first quartile in mean years of schooling (MYS) and skills in literacy adjusted mean years of schooling (SLAMYS), 1970–2015. Calculations are based on data from the PIAAC Survey of Adult Skills (30), the World Bank's STEP Skills Measurement Program (31), the Demographic and Health Survey (32), the WIC Human Capital Data Explorer (20), the International Adult Literacy Survey (29), UIS statistics (33), and the global dataset on education quality (34). Countries are ranked based on their average SLAMYS between 1970 and 2015.

our findings for policymakers at all levels, we want to conclude by accentuating the need for internationally comparable widespread testing of adult skills beyond literacy, which would enable us to further extend our analyses to additional skill domains.

Materials and Methods

Our analyses throughout this paper exclusively focus on literacy skills, as literacy assessments are available for the largest number of countries. Sensitivity analyses revealed, however, that literacy skills are highly correlated with other skills domains, thus also providing a good proxy for the overall skill level in the population—particularly when considering them at the aggregate level. More details on the correlations between literacy skills and other types of skills can be found in *SI Appendix*.

Our empirical exercise relies on data harmonization, demographic modeling, and statistical estimation for 185 countries. More specifically, the SLAMYS dataset was developed in three steps: First, for 44 countries SLAMYS were computed using comprehensive adult literacy skills data from three different survey types: IALS (29), PIAAC (30), and STEP (31). Second, to increase coverage among developing countries, we used DHS tested literacy data (32) to provide skills adjustments for 59 additional countries. Finally, to expand the dataset to a global scale, we used a prediction regression model for countries where no empirical adult skills data are available. This statistical estimation model included, among others, adult literacy, school enrollment rates, educational expenditure, and pupil–teacher ratios from the UNESCO Institute of Statistics (33), and harmonized learning scores from the Global Dataset on Education Quality (34). Data for MYS by country, age, and sex were retrieved from the WIC Human Capital Data Explorer (20).

As our estimates are based on the average performance of populations, our standard of comparison for the literacy skills adjustment equals the 2015 population-weighted OECD mean PIAAC literacy test score, calculated separately for males, females, 5-y age groups, and four educational attainment categories. The skills adjustment was designed in such a way that, for the standard of comparison, the MYS is set to be equal to the SLAMYS for OECD. As a consequence, if a country's age–sex–education subpopulation group performs worse than the population-weighted OECD mean, its SLAMYS will be lower than its MYS; accordingly, for any country-specific age–sex–education subpopulation group, which scores better than the OECD mean, the opposite holds. Demographic modeling techniques were applied to consider the temporal evolution of SLAMYS since 1970: Time-series estimates rest on the reconstruction of mean literacy test results along cohort lines, based on observed age effects from countries where adult literacy skills data exist for more than one point in time. A more detailed description of data sources used and methods applied can be found in *SI Appendix*.

Data Availability. All study data are included in the article and/or supporting information.

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