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DEBATE

The growing gap in cognitive skills within and between countries

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ABSTRACT In this contribution two recent studies on the inequality of trends in cognitive skills are discussed. One uses longitudinal data on tested adult literacy and numeracy in Germany and finds that for the more educated and those in intellectually demanding jobs, skills continue to improve up to higher working ages, while for those with low starting levels and blue-collar jobs, skills start to decline already in the thirties. Another study estimates global level trends in skills in literacy adjusted mean years of schooling and finds a growing gap in skills between countries, despite some convergence in formal educational attainment levels. This article discusses selected possible consequences of this growing inequality in skills within and between countries, and outlines a further research agenda.

KEYWORDS Education • Inequalities • Cognitive skills • Adult literacy • Adult numeracy

Introduction

Education and the associated literacy and numeracy skills are widely acknowledged as having important implications, both at the individual level in terms of empowerment, health and income, and at the aggregate level of populations in terms of socio-economic development and the quality of institutions in general. A first look at trends in global education statistics seems to convey the reassuring picture that the world has been moving towards convergence in educational attainment levels over the past two decades, in particular due to a rapid expansion in basic education in many African countries following the Millennium Development Goals (MDGs) in 2000. However, a closer look at the trends in tested skills, rather than in formal school enrolment and attainment, indicates that much of the educational expansion has occurred with parallel declines in the quality of education, and that there seems to be a widening global gap, rather than a convergence, in actual skills. Similarly, within rapidly ageing industrialised countries, there is recent evidence of a growing skills gap between different segments of the population, which may also have broader social and political implications.

This contribution will first highlight the key findings from two recent studies, and will then briefly discuss the possible implications of these trends of increasing cognitive inequality. It first discusses a recent contribution by Hanushek et al. (2025) focusing on skills changes over the life cycle for different sub-groups of the population using longitudinal data

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from Germany. The key finding of this study with respect to skills is succinctly summarised in the sub-title, which states that individuals must "use them or lose them". The other study (Lutz et al., 2021a) adjusts time series of educational attainment distributions and of mean years of schooling for most countries in the world with recently available information on the tested literacy skills of adults, introducing the new indicator of skills in literacy adjusted mean years of schooling (SLAMYS). Its findings are also succinctly summarised in the title: "Skills-adjusted human capital shows rising global gap".

The differential loss of cognitive skills with age

The study by Eric Hanushek (Stanford), Lavinia Kinne, Frauke Witthöft and Ludger Woessmann (various German institutions) published in Science Advances (2025) starts out with some surprisingly good news. It challenges the long-standing belief that cognitive skills such as functional literacy and numeracy begin to decline by age 30. This belief has fuelled concerns about the economic and societal consequences of ageing populations. If adults start losing cognitive abilities early in their working lives, societies with ageing populations may face significant challenges in maintaining productivity and economic vitality. However, much of the evidence for early cognitive decline is based on cross-sectional studies that conflate ageing with generational (or cohort) differences. These studies compare individuals of different ages at a single point in time, which makes it difficult to determine whether the observed differences in skills are truly due to ageing, or instead reflect the different life experiences, educational backgrounds and societal changes that distinguish older and younger generations.

The Hanushek et al. (2025) study overcomes the limitations of cross-sectional data by using a unique longitudinal dataset from Germany. The data come from the Programme for the International Assessment of Adult Competencies (PIAAC), administered by the OECD, which measures adults' literacy and numeracy skills and collects detailed information on their backgrounds and daily skills usage. What sets Germany apart from other participating countries is that it followed up with a panel of participants from the original PIAAC sample and retested them approximately 3.5 years later. This allows researchers to observe how individuals' skills actually change over time, providing a much more accurate picture of cognitive ageing than is possible with cross-sectional data or synthetic cohorts.

The findings reveal that rather than undergoing a straightforward early decline, the average literacy and numeracy skills of individuals increase significantly into their forties. Across all sub-populations, literacy tends to peak at around age 46 and then plateaus, while numeracy peaks slightly earlier, at around age 41, and then declines more steeply. These patterns diverge from the earlier declines reported in previous cross-sectional studies (Desjardins and Warnke, 2012), which the authors argue are misleading due to the failure to separate true ageing effects from differences across birth cohorts. In other words, the older cohorts have lower education/skills to start with compared to the younger cohorts, and what looks like a decline with age is actually due to differences in skills between cohorts.

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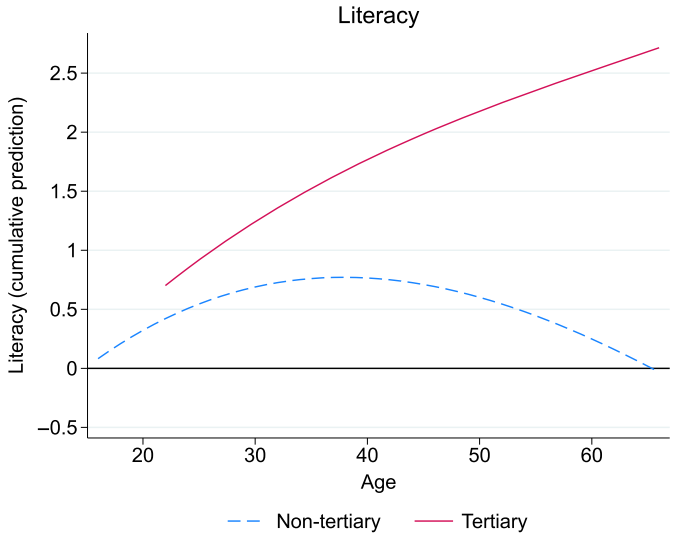
These average trends, however, mask important differences between individuals. The authors find significant heterogeneity in skills trajectories based on how frequently individuals use their skills in daily life. People who engage more often in activities involving reading and math – whether at work or at home – tend to maintain or even improve their skills well into their fifties. In contrast, those with below-average usage experience noticeable declines, particularly starting in their mid-thirties. This pattern suggests that cognitive skills retention is not simply a matter of biology or ageing, but is closely tied to how actively individuals engage their cognitive abilities.

Similar differentials appear when looking at occupational status and highest completed education level. White-collar workers and those with tertiary education are more likely to use their literacy and numeracy skills frequently, and correspondingly show continued improvement or stability in these skills as they age. Blue-collar workers, who typically use such skills less often, are more likely to experience early declines. These differences are consistent across literacy and numeracy skills, even though numeracy generally declines more sharply at later ages.

Figure 1 illustrates this pattern with respect to age trajectories in literacy skills. It shows the increasing gap with age between those who have tertiary education and those with lower educational attainment. The results with respect to numeracy are very similar. Gender differences also emerge, with women experiencing steeper declines in numeracy than men at older ages. This could be partially explained by patterns of skills usage, as women report lower average engagement with numeracy-related tasks, especially in the workplace.

Figure 1 Changes in literacy skills with age for people with tertiary and non-tertiary education (y-axis shows predicted score from regression model in Table 1 in Hanushek et al. (2025))



Source: Hanushek et al. (2025) (CC BY).

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This finding is robust across different domains – both literacy and numeracy – and is not merely an artefact of including younger individuals who may still be in education. When the analysis is limited to adults aged 25 and older, the patterns remain the same. Moreover, the relationship between skills usage and skills retention is observed regardless of whether the skills are used at work or at home, indicating that any kind of regular cognitive engagement can help preserve skills.

Thus, this study provides a far more optimistic view of cognitive ageing than previous research has. Rather than being doomed to decline by midlife, adults can continue to improve or at least maintain their cognitive skills well into their fifties, especially if they stay cognitively active. The findings have significant implications for policy and practice. For one, they suggest that encouraging lifelong learning and cognitive engagement – whether through continued education, intellectually demanding work or hobbies – can help preserve essential skills and offset the effects of ageing. For employers and policymakers concerned about the productivity of older workers, the results underscore the value of investing in opportunities that promote using and further strengthening skills throughout the life course.

However, despite this optimistic overall message, the study also points to the stunning differences in the age trajectories of different groups of people. On the one hand there are men and women who start out with higher education, work in white-collar jobs and continue to use their skills. The literacy and numeracy skills of these individuals continue to increase well into their sixties (people above 65 are not included in this study). By contrast, for the other group consisting of people with less than tertiary education and people who do not use their literacy skills as much in either their daily lives or their jobs, the skills seem to peak at an already rather low level between ages 35–40 and then start to decline. As Figure 1 indicates, by the age of 60–65, this gap between the two groups starts to become huge, with far-reaching consequences for issues ranging from social participation at older ages to employability in the context of increasing retirement ages. Moreover, as populations age and higher proportions of the total population move into the age groups in which the gaps are particularly pronounced, the societal and economic consequences of these disparities will be felt even more strongly.

The Hanushek et al. (2025) paper also has a positive policy message, based on the finding that cognitive decline in adulthood is not inevitable. While some decline may eventually occur, especially in numeracy, the timing and the extent of that decline are far more variable than previously thought – and, critically, they are influenced by how people use their skills in daily life. With the right kinds of engagement, many adults can not only retain their skills, but can continue to develop them well into their later years.

The growing global gap in skill levels between groups of countries

The second study discussed here is authored by Wolfgang Lutz, Claudia Reiter, Caner Özdemir, Dilek Yildiz, Raquel Guimaraes and Anne Goujon (all associated with the Wittgenstein Centre for Demography and Global Human Capital (IIASA, ÖAW, University of Vienna)), and is published in PNAS (2021a). Entitled "Skills-adjusted human capital

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shows rising global gap", the paper presents a new reassessment of how human capital is measured globally, highlighting growing disparities between countries in terms of adult skills. While education has long been seen as central to development – from the days of ancient philosophers to the modern Sustainable Development Goals – the paper argues that traditional measures of education based exclusively on the length of formal education and formal educational attainment have significant shortcomings. They propose to go beyond the widely used indicators of years spent in school, which ignore whether those years translate into actual skills that can contribute to personal and societal income growth and wellbeing.

At the heart of this paper is the introduction of a new metric called the skills in literacy adjusted mean years of schooling (SLAMYS). This indicator differs from the conventional mean years of schooling (MYS) metric by taking into account not just how long people go to school, but how much they actually learn and retain as adults. The authors argue that SLAMYS is a much more accurate and meaningful representation of human capital. It is built using large-scale international datasets that assess adult literacy and numeracy across age groups and education levels. In doing so, it fills a major gap in current knowledge by providing, for the first time, a demographically consistent and globally comparable time series of adult skills.

Another innovative feature of the SLAMYS approach is that it incorporates how skills evolve after formal education ends. Using synthetic cohort data, the authors show that skills do not remain static over a lifetime. Highly educated individuals often gain or maintain skills well into middle age, while those with less education tend to lose skills more rapidly after leaving school. This important finding fully corresponds to the results outlined in the Hanushek et al. (2025) paper, which are described in more detail above. The Lutz et al. (2021a) paper also uses these insights for modelling the change in skills over the entire life cycle differentiated by educational attainment level. Since such longitudinal information is not available for all countries, assumptions about standard skill loss schedules by level of education had to be made.

The empirical basis for this study covers time series for 185 countries based on data harmonisation, demographic modelling and statistical estimation. Adult skills assessments were drawn from four major surveys: IALS, PIAAC, STEP and DHS. Educational attainment distributions and mean years of schooling (MYS) by age and sex for 1970–2015 were sourced from the Wittgenstein Centre Data Explorer, Version 2 (https://dataexplorer.wittgensteincentre.org/wcde-v2/). For countries lacking empirical data on tested literacy skills, the models used proxies like adult literacy, school enrolment, education spending, pupil-teacher ratios (UNESCO) and harmonised learning scores from the Global Dataset on Education Quality to estimate adult skills. The methods and assumptions used in this rather complex exercise are fully documented in the online appendix of the PNAS paper (Lutz et al., 2021a), and will not be further discussed here. The result is a comprehensive and comparable dataset for analysing global human capital trends incorporating the skills dimension for 185 countries for the 1970–2015 period.

While the conventionally measured mean years of schooling (MYS) show impressive growth, especially in developing nations that have significantly expanded access to schooling, SLAMYS tells a more sobering story. The global average MYS nearly doubled

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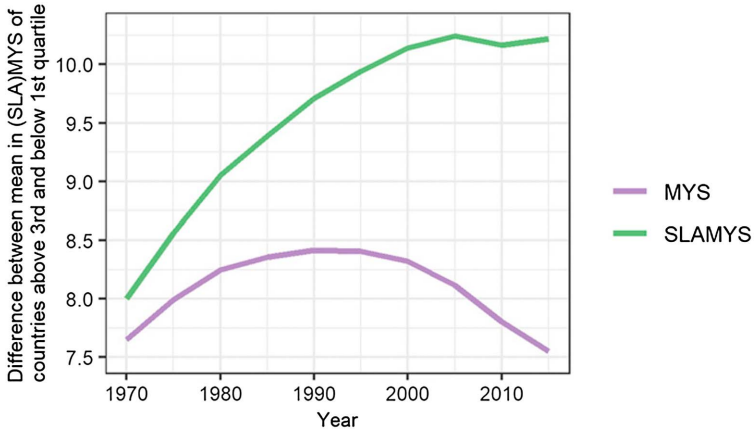
from 4.81 years in 1970 to 8.53 years in 2015, reflecting the success of policies promoting universal education. However, SLAMYS rose from only 3.73 to 6.88 during the same period, indicating that while more people are attending school, they are not necessarily acquiring the skills needed to thrive in modern economies.

This distinction becomes more pronounced when comparing specific regions and countries. For instance, East Asia experienced a dramatic rise in SLAMYS, from 3.16 in 1970 to 8.35 in 2015, showing strong improvements in both access to and quality of education. Sub-Saharan Africa, by contrast, made much less progress, with SLAMYS increasing from a very low level of 0.79 to only 3.19 over the same period. That puts the region nearly half a century behind East Asia in terms of skills. This very slow progress suggests that expanding school access without a simultaneous investment in education quality is not enough to build human capital.

The paper also presents a rich set of country-specific data that can be used to analyse contrasting evolutions. South Korea, for example, made tremendous strides in improving both access to education and the quality of its outcomes over the past decades. Its SLAMYS score more than doubled between 1970 and 2015, surpassing even that of the United States. In contrast, countries like Nigeria and Ghana saw large increases in MYS, indicating that more people were attending school, but their SLAMYS rose only marginally. That suggests that even though people were spending more time in school, their actual skills acquisition remained very low.

Figure 2 clearly illustrates the growing global gap in skills over time. It compares the interquartile range of MYS and SLAMYS across countries and time. While MYS shows signs of convergence, with low-performing countries catching up after 1995 in terms of average years spent in school, the SLAMYS gap continues to widen. This suggests that

Figure 2. 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



Source: Lutz et al. (2021a) (CC BY-NC-ND).

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the quality of education is not improving uniformly, and that in many places, it may even be deteriorating.

The Lutz et al. (2021a) paper marks a significant advance in how we understand and model human capital. It combines an existing global dataset of educational attainment distributions by age and sex for all countries since 1950 (from the Wittgenstein Centre Data Explorer) with newly available data on tested literacy scores (by age and sex) that are reconstructed along cohort lines based on the above-described education-specific trajectories of skills losses/gains with age. By focusing directly on adult skills, it also goes beyond previous studies that assessed the quality of education through the testing of in-school populations, as is done in PISA.

The authors conclude that the global focus on educational expansion must urgently shift towards improving educational outcomes. They caution that the COVID-19 pandemic, which was associated with total school closures of up to two years in some African countries – a period that is not yet covered by the existing skills data – may further erode future skills levels, especially in vulnerable regions where remote learning was inaccessible. With such high stakes, the paper calls for a re-evaluation of educational priorities and policies. Governments, development agencies and researchers must pay more attention to actual learning outcomes and invest in assessments, teacher training and curricula that prioritise critical thinking, literacy and numeracy.

Outlook and challenges for research

The two recent papers discussed above bring the discussion of the importance of human capital for all kinds of personal-, societal- and global-level benefits to a new level. They show that improvements in human capital, which also considers actual skills rather than only the length of formal school attendance, are not following the smooth upwards trajectory that is often assumed. And, above all, they find significant heterogeneity in those trends, both over individual life cycles as well as in the development trajectories of different countries across the world.

These new insights call for new empirical assessments of the role of human capital in many desirable dimensions of sustainable development. Conventional econometric analyses of the role of education in economic growth have mostly used the indicator of mean years of schooling (MYS) as an explanatory variable, and have yielded mixed results (de la Fuente and Doménech, 2024). An explicit consideration of age-specific educational attainment distributions as a human capital indicator produced significantly better and more consistent results in terms of establishing education as a key driver of GDP growth (Lutz et al., 2008). While the desirability of explicitly adding the skills dimension to the human capital variables has often been expressed, until recently, there were no consistent international time series data on adult skills. Analyses that used scholastic test results as a proxy for national adult skill levels clearly indicated that these indicators have significant additional explanatory power (Hanushek and Woessmann, 2007). The data presented in the PNAS paper discussed above with SLAMYS time series for 185 countries offer an opportunity to systematically re-estimate the economic growth regressions using this more appropriate

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indicator of adult skills that are not only based on adult literacy testing, but also incorporate the changes in skills over the life cycle, or at least during working ages.

Beyond studying the drivers of economic growth, skills adjusted human capital data should also be applied to estimating the returns to investment in quality education for other outcomes ranging from health and the adaptive capacity, to climate change, to general well-being. Here, the recently proposed wellbeing indicator of years of good life (YoGL), which has been tailor-made for the study of sustainable development (Lutz et al., 2021b), should also be analysed as a function of SLAMYS. Since YoGL has also been estimated for time series of a large number of countries, this should be possible, even in the context of a systems model that tries to incorporate possible feedback loops from environmental change to the constituents of sustainable wellbeing, as has recently been proposed in Kuhn et al. (2023).

The next challenge on the table is to project skill levels and to explicitly integrate the skills dimension into human capital population projections scenarios up to the end of the century. The "human core" of the Shared Socioeconomic Pathways (SSPs) (KC and Lutz, 2017) gives five alternative consistent long-term scenarios for future population size and structures by age, sex and levels of educational attainment, which are now widely used in the context of climate change modelling and analysis. The SSP scenarios have so far provided 4–6 educational attainment distributions by age and sex. They also feed into the consistent economic growth assumptions, health outcomes and adaptive capacity/vulnerability to climate change. There are many other uses of these scenarios. According to the latest available data, the Shared Socioeconomic Pathways (SSPs) were utilised in over 2600 studies between 2014 and 2021. To my knowledge, none of these studies considered the quality/skills dimension of human capital.

To explicitly incorporate the skills dimension into the SSP scenarios, the new analytical insights as described above should be operationalised for use in the multi-dimensional demographic projection model that underlies the human core of the SSPs. This is a significant effort that will be carried out under the Yidan Prize Project (https://iiasa.ac.at/projects/supported-by-yidan-prize-project-funds) led by the author, and that will, starting in 2025, initially focus on selected African counties. In collaboration with the UNESCO Institute of Statistics (UIS) and UNESCO's Global Education Monitoring Report (GEM), this project will include an estimation of the best possible baseline population data for the populations specified by age, sex and level of formal educational attainment, with each attainment category sub-divided into a high and a low skills group. The basis for this sub-division will be the average tested skills level at the given attainment category in a group of countries (in the Lutz et al. (2021a) paper described above, the cut-off points were the average skills in each category over all OECD countries while for this new study, an African average will likely have to be chosen to avoid too skewed distributions).

This new effort for integrating the skills dimension into global education scenarios will be accompanied by another innovation in education modelling and forecasting. It will try to incorporate the intergenerational transfer of educational attainment and skills, which is widely considered a major determinant of education heterogeneity, since the children of more educated parents have higher chances of obtaining a better education themselves. While this mechanism of education dynamics has so far only been operationalised with

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respect to formal educational attainment (Marois et al., 2019a,b), in this project we will attempt to develop a model in which the skills of the mother (within each educational attainment category) will influence the probability of the child both reaching a certain attainment level and acquiring the skills within this level. This mechanism will be assumed to work in tandem with government policies affecting both the attainment of formal education levels as well as the acquisition of skills upon school completion and the maintenance of these skills over the life course.

This section has outlined the research and modelling strategy for estimating the long-term returns to near-term investments in quality education on a wide spectrum of outcome variables, together with a strategy for the incorporation of the skills dimension into global-level education scenarios. These proposed next steps present major research challenges that need to be resolved over the coming years. Already at this stage we can conclude that the empirical insights from the two recent studies summarised here also indicate major political, social and economic challenges resulting from the expected increase in future inequalities in skills within and between countries.

As the global economy becomes increasingly knowledge-driven, literacy and numeracy skills will be critical in determining whether individuals and countries are well equipped for the future. This is unlikely to be achieved by simply expanding years of schooling without delivering the skills that matter, including the increasingly important digital skills. Since skills seem to be the real engine behind economic growth, social cohesion and adaptation to environmental change, ignoring the quality of education and adult skills risks deepening global inequalities.

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