Learning achievement and education system reform in low- and middle-income countries

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Abstract

The world has long committed to ensuring a quality education for every child (United Nations 1948). Yet, while school enrolments have increased dramatically over the past 50 years, learning has remained low; many children who are in school are not achieving even basic learning outcomes. The nine papers being submitted towards this PhD by Publication make four main contributions: they develop and employ new methods to study children's learning achievements, assess the consequences of poor learning for later life outcomes, propose new ways to model key policy choices to improve learning, and investigate the role of system coherence for improving learning outcomes. First, I analyse data using learning trajectories, rather than the standard approach of using single point-in-time learning outcomes, to study children's learning as they progress through school. Second, I investigate the role of learning in later life outcomes, including women's fertility, empowerment, and child mortality. Third, I develop a structural model of the learning process and use it to model education policy outcomes. The model suggests that achieving universal grade 10 completion would produce little literacy gain as children are too far behind to gain much learning from the additional years. However, slowing the pace of the curriculum to better match children's pace of learning could increase learning levels by the equivalent of 1.6 years of schooling. Fourth, I investigate the role of education system coherence in driving learning outcomes. I use the Surveys of Enacted Curriculum to quantify instructional misalignments in Uganda and Tanzania, and an education system diagnostic approach to describe reform coherence in Brazil and Indonesia. Taken together, these papers contribute to the emerging field of systems thinking in international education research.

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Critical analysis

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1. Introduction

Beginning with the Universal Declaration of Human Rights in 1948, the world has committed to ensuring a quality education for every child (United Nations 1948). In 1990, the World Declaration on Education for All reiterated this commitment, specifying that "Every person – child, youth, and adult – shall be able to benefit from educational opportunities designed to meet their basic learning needs" (World Conference on Education for All 1990). Sustainable Development Goal 4 (SDG 4) further reinforced these commitments in 2015, including with targets for learning outcomes (United Nations General Assembly 2015).

Since the time of the 1948 Declaration, school enrolment rates have risen dramatically. Globally, between 1950 and 2010, the percentage of the population aged 15 years or older with at least some schooling rose from 52.9% to 85.2% (Barro and Lee 2013). In developing countries, average years of schooling grew from 2.02 years in 1950 to 7.20 years in 2010 (Barro and Lee 2013). As of 2023, primary school completion rates were 88% globally (UNESCO 2024). Nearly all children now attain at least some schooling.

However, learning has remained low. In five out of six African countries included in a UNESCO study on learning achievements, less than 15% of children met or exceeded the SDG target for reading[1] (UNESCO Institute of Statistics 2022). In India, just 21% of children in grade 3 can read a grade 2 level text and just 26% of children in grade 5 can solve a simple division problem (ASER Centre 2023). In Uganda, only 33% of children in grades 3-7 can read and comprehend a grade 2 level story and less than half can solve a grade 2 level mathematics problem (Uwezo Uganda 2019).

Now that most children are in school, the frontier in international education research and practice is how to ensure they learn while there. This critical analysis reviews nine published papers being submitted towards a PhD by Publication that contribute to this topic. Table 1 provides an overview of these papers, while Appendix 1 reports the full references. These papers use novel approaches to document and measure learning outcomes, investigate the consequences of low learning for later life outcomes, model policy approaches to improve learning, and refine the hypothesis that system incoherence for learning constrains learning, suggesting that, by inference, improving coherence for learning is key for improving outcomes. Together, these papers contribute to the new and growing field of systems thinking within international education research.

The first set of papers analyses data using learning trajectories, departing from the standard approach of using single point-in-time learning outcomes, to investigate children's learning as they progress through school. The first paper in this set uses unique, nationally representative data on adult learning levels in 10 LMICs across Africa and Asia, finding that only half of young adults who completed

[1] Countries included Burkina Faso, Burundi, Cote d'Ivoire, Kenya, Senegal, and Zambia. Kenya was an outlier, with 46.7% of students demonstrating proficiency in reading.

primary school achieved foundational literacy (Kaffenberger and Pritchett 2020) (paper 1, Table 1). Furthermore, even if all had completed primary school, literacy would have increased by only eight percentage points on average.

The second paper in this set further uses learning trajectories to propose a novel conceptual and empirical definition of education poverty which takes learning dynamics into account (Kaffenberger, Pritchett, and Viarengo 2023) (paper 2, Table 1). The paper defines a low, extreme education poverty standard and a higher, global education poverty standard, aligning with approaches to measuring income poverty (Jolliffe and Prydz 2016; Ravallion, Datt, and van de Walle 1991). The findings confirm that the overwhelming obstacle to addressing education poverty is not school grade attainment, but the insufficient pace of learning, hindering children from achieving minimum standards.

The second set of papers examines the role of learning in later life outcomes. While it is well established that education improves both pecuniary and non-pecuniary outcomes (Psacharopoulos and Patrinos 2004; Gakidou et al. 2010), most studies use years of schooling as a proxy for education without accounting for variation in learning across children per year. Drawing on data from more than 50 countries, the first paper in this set investigates the separate roles of school grade attainment and literacy achievement in girls' later life outcomes (Kaffenberger and Pritchett 2021b) (paper 3, Table 1). The findings reveal, for instance, that while completing primary school alone is associated with a 26% reduction in later child mortality, completing primary school and achieving basic literacy is associated with a 70% reduction.

The second paper in this set uses unique longitudinal quantitative and qualitative data for Ethiopia, India, Peru, and Vietnam to investigate the association between learning and schooling persistence (Kaffenberger, Sobol, and Spindelman 2023) (paper 4, Table 1). The findings show that a one standard deviation higher math score at age eight is associated with a 50% reduction in the odds of children dropping out by age 12. Additionally, complementary qualitative analysis indicates that parents often choose to discontinue schooling when they find their children are learning little, and girls often choose marriage over staying in school when they realise their learning progress is minimal.

A third set of papers develops a structural model of the learning process and uses it to model outcomes of varied policy approaches. The global health field has a long history of using modelling to inform health policy decision-making (Dodd et al. 2017; Stenberg et al. 2019; Pichon-Riviere et al. 2020), but similar modelling is not common in education. In the first paper in this set, the parameterised structural model suggests that increasing schooling to universal grade 10 completion would produce little gain to literacy levels, as most children are too far behind the level of instruction to gain much learning from the additional years in school (Kaffenberger and Pritchett 2021a) (paper 5,

Table 1). Slowing the pace of curriculum to better match children's pace of learning, however, would increase grade 10 learning levels by the equivalent of 1.6 years of schooling, by reducing the number of children falling behind.

The second paper in this set uses the model to analyse the potential long-term consequences of Covid-19 induced school closures on learning (Kaffenberger 2021) (paper 6, Table 1). Without adequate catchup programmes, the model shows that initial learning losses of one-third of a year's worth of learning could continue accumulating even after children return to school, growing to over one year's worth of learning loss. The model suggests that keeping remediation policies in place long term, to help children keep up with the level of instruction, could more than make up for learning losses.

The final set of papers examines the concept of education system coherence and its role in learning outcomes. Systems thinking is receiving increasing attention in the international education sector (Faul and Savage 2023; Global Partnership for Education 2022), as growing evidence shows that isolated educational inputs typically do not improve learning (Glewwe, Kremer, and Moulin 2009; Mbiti et al. 2019). The first paper in this set uses the Surveys of Enacted Curriculum (SEC) (Blank, Porter, and Smithson 2001; Porter 2002) to empirically quantify the content and alignment of primary curriculum standards, national exams, and teacher classroom instruction in Uganda and Tanzania (Atuhurra and Kaffenberger 2022) (paper 7, Table 1), representing the first application of the methodology in LMICs. The analysis identifies multiple areas of misalignment. For instance, for English, the Ugandan curriculum places two-thirds of its emphasis on just three topics, comprehension, language study, and speaking and presenting, while teachers spread their coverage across 14 topics and prioritise low levels of cognitive demand such as memorisation.

The second paper in this set uses an education systems framework (Moore 1995; World Bank 2004; Pritchett 2015) and a case study approach to analyse the coherence of reform efforts in Brazil and Indonesia (Kaffenberger and Spivack 2023) (paper 8, Table 1). The final paper reviews three approaches, one quantitative and two qualitative, for analysing education system coherence for learning at the curricular, instructional, and reform level (Kaffenberger, Silberstein, and Spivack 2023) (paper 9, Table 1). The findings from these papers support the hypothesis that system coherence is an important factor in learning outcomes.

This critical analysis reviews each paper in turn, as listed in Table 1.

Table 1 Papers being submitted towards PhD by Publication

Section(s) where papers are discussed	Papers submitted towards PhD by publication
2.1	Paper 1. Kaffenberger and Pritchett (2020)
2.2	Paper 2. Kaffenberger, Pritchett and Viarengo (2023)
3.1	Paper 3. Kaffenberger and Pritchett (2021b)
3.2	Paper 4. Kaffenberger, Sobol, and Spindelman (2023)
4.1	Paper 5. Kaffenberger and Pritchett (2021a)
4.2	Paper 6. Kaffenberger (2021)
5.1	Paper 7. Atuhurra and Kaffenberger (2022)
5.2	Paper 8. Kaffenberger and Spivak (2023)
5.3	Paper 9. Kaffenberger, Silberstein, and Spivak (2023)

Note: Full references are available in Appendix 1.

2. Measuring learning outcomes

Most standard national, regional, and international learning assessments measure children's learning levels only at a particular age or grade level, limiting their ability to detect when children begin to fall behind and where extra learning support is most needed. For instance, the Programme for International Student Assessment (PISA) and PISA for Development (PISA-D) assess only 15-year-olds currently enrolled in school (Sellar and Lingard 2014). The Southern and Eastern Africa Consortium for Monitoring Education Quality (SACMEQ), a regional assessment, measures learning only among sixth-grade students. While these assessments provide valuable, cross-country comparable information on children's learning achievements (Fehrler, Michaelowa, and Wechtler 2009; Howie 2022), they do not provide information on children's learning pathways as they progress through school.

To address these gaps, novel types of learning assessment data have emerged. Recent survey rounds of the Demographic and Health Surveys (DHS), nationally representative household surveys, introduced an enumerator-administered literacy assessment, which has been used for monitoring SDG 4 (UNESCO 2020). UNICEF's Multiple Indicator Cluster Surveys (MICS) recently began administering adult and child literacy assessments as a part of their household surveys (Thorn 2020). Citizen-led assessments such as the Annual Status of Education Report (ASER) in India and Uwezo in East Africa assess children of all primary school grades and ages (Banerji, Bhattacharjea, and Wadhwa 2013; Mugo et al. 2015). These assessments all cover children or adults with varied levels of school completion.[2]

[2] It should be noted that while these novel surveys provide helpful insights and have been administered in countries and contexts where evidence was missing, caution should be exercised in using them to make grand

2.1 Learning trajectories across 10 LMICs

The advent of novel learning assessment data enables a new type of learning analysis: learning trajectories. Learning trajectories are a descriptive, analytic approach for investigating children's average learning progressions, representing the empirical relationship between years of schooling and learning achievement. This novel analytical technique enables targeting of policies and interventions not only to the children who most need them, but also at the point in the schooling process when children need them most.

In the first paper submitted towards this PhD by Publication, my coauthor and I use unique, nationally representative, cross-sectional data on young adult schooling attainment and learning levels to analyse learning trajectories across 10 LMICs across Africa and Asia (Kaffenberger and Pritchett 2020) (paper 1, Table 1).[3,4] We use data from the Financial Inclusion Insights (FII) surveys, which include an enumerator-administered assessment of adults' functional literacy. By combining the data from the literacy assessment with the highest level of schooling completed by young adults, we analyse average literacy by schooling level completed and use the resulting learning trajectories to simulate policy approaches to improve learning.[5] It is important to note that these learning trajectories represent correlations between schooling attainment and learning achievement, rather than causal relationships[6], and should be interpreted as average learning trajectories at the systems level, rather than learning trajectories of individual children (the analysis of which would require longitudinal data).[7]

The first finding reveals that in six out of the ten countries, half or less of young adults who completed primary school as their highest level achieved basic functional literacy (Figure 1). Additionally, learning trajectories show that learning is highly varied across countries. Literacy levels among young adults with primary school as their highest level range from 20% in Bangladesh to 80% in Tanzania. Literacy learning trajectories through primary school are steeper in Tanzania and

claims as some of them lack the quality and depth of learning measures used in other assessments and for some the administration has been subject to criticism.

[3] The terms 'learning trajectories' and 'learning profiles' are used interchangeably. In this critical analysis I use the term 'learning trajectories' for consistency; in Kaffenberger and Pritchett (2020) we used the term 'learning profiles'.

[4] Countries included Bangladesh, Ghana, India, Indonesia, Kenya, Nigeria, Pakistan, Rwanda, Tanzania, and Uganda.

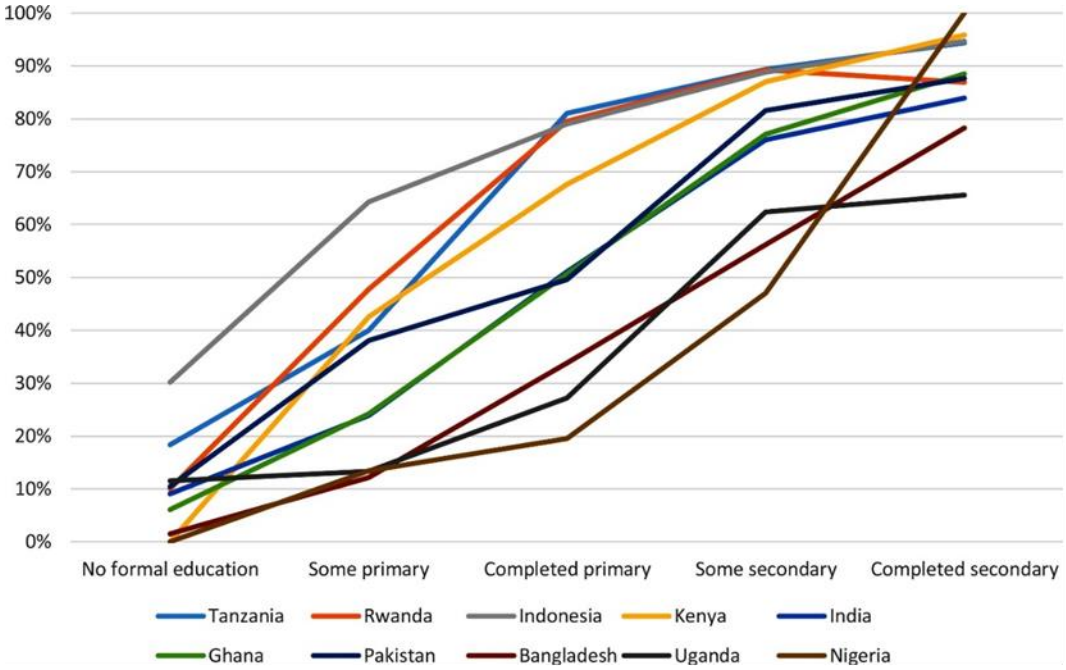
[5] The literacy test in the FII surveys is a relatively low bar for literacy and is used in this analysis as a proxy for broader learning achievement.

[6] Concerns often arise regarding potential over-estimation of relationships due to omitted variables and selection biases. However, most learning trajectories analyses show very low learning achievement per year in LMICs. If these estimates are indeed biased upward, then causal trajectories would show even flatter trajectories, reinforcing the findings of low average trajectories.

[7] See, for instance, Global Education Monitoring Report Team (2021) and Bau, Das, and Yi (2021) for discussions of non-linearity of individual children's learning trajectories.

Rwanda, while in Nigeria and Uganda they are relatively flat, with only small increases in literacy through primary school completion.[8]

Figure 1 Learning trajectories across ten LMICs: Percent literate at each schooling level



Source: Kaffenberger and Pritchett (2020), using nationally representative Financial Inclusion Insights data.

Next, we use the learning trajectories to simulate multiple policy priorities (Kaffenberger and Pritchett 2020). Initially, we simulate universal primary school completion, which is a common national policy objective. Using equations 1 and 2, we simulate how literacy levels would change if all young adults who did not complete primary school instead had completed primary school at the average learning trajectory for that country. The actual literacy *L* in a country *i* can be represented as L_i:

$$L_i = \sum_{l=0}^{l} \alpha_{li} * s_{li} \qquad (1)$$

Where α_{li} is the share of young adults in country *i* with level *l* as their highest level of schooling attainment, and s_{li} is the share of young adults in country *i* with highest schooling attainment of *l* who have achieved basic literacy. To simulate universal primary completion, we assume all young adults with less than primary completion (*l* = 0 or 1) instead complete primary school, achieving the average

[8] These differences across countries are not surprising. Rwanda and Tanzania, for instance, have one to two primary spoken languages, while Nigerians speak more than 500 different native languages. Alignment between children's mother tongue language, or the language spoken at home, and the language of instruction, has important implications for achieving foundational literacy skills.

literacy of those who completed primary school (l = 2). Simulated counterfactual literacy for country i in this scenario (L_i^S) is:

$$L_i^S = \sum_{l=0}^{1} \alpha_{li} * s_{2i} + \sum_{l=2}^{5} \alpha_{li} * s_{li} \qquad (2)$$

The gains in literacy in the counterfactual scenario will be larger when a larger share of young adults have not completed primary school and when the learning trajectory is steeper in primary school. The simulations suggest this scenario would increase literacy levels by only eight percentage points on average, leaving 27% of young adults functionally illiterate. The reason for the modest literacy gain is twofold. First, most young adults, 76% on average across the 10 countries, completed primary school, so achieving universal primary completion would have only affected about a quarter of young adults. Second, the typical pace of learning is so shallow that the additional years of schooling would have added little to the literacy level.

We next simulate a series of gender equality scenarios, using the same method as in the schooling completion simulations. These simulations find, for instance, that if young women had the same schooling attainment levels as young men but maintained their current learning trajectories, their literacy would increase on average by only seven percentage points, leaving 34% of young women illiterate. Achieving equality yields only limited learning gain for young women due to the shallow learning trajectories observed for both young women and young men on average. In our final simulations, we find that steepening learning trajectories to match those of the best-performing of the ten countries – Indonesia – would yield greater gains in literacy levels than achieving universal primary schooling or gender equality.

This study is part of a growing body of research and practice using learning trajectories. Barros and Ganimian (2023), for instance, analyse learning trajectories for children's mathematics skills in India. Bau, Das, and Yi Chang (2021) explore learning trajectories using longitudinal data from Pakistan, finding significant variation in children's learning by initial achievement level. Learning trajectories also serve as an input to a new macro measure of education, Learning-Adjusted Years of Schooling (LAYS) (Filmer et al. 2020). Among practitioners, UNICEF and UNESCO have both taken up the use of learning trajectories analysis (UNICEF 2022; UNESCO 2022).

There may be tradeoffs in the use of learning trajectories, as they require data from multiple grade levels or ages, compared with simpler measures of learning. However, learning trajectories provide a much richer set of information, including when children tend to fall behind expectations in the schooling progression, and the extent to which trajectories differ across student groups revealing which groups may need enhanced support, among others. Numerous existing data sources contain information suitable for analysing learning trajectories, and the availability of appropriate data is

growing, thereby enhancing the viability of this approach.2.2 Learning trajectories as a basis for a new definition of education poverty

As acknowledgment of low average learning achievement grows, the need to define and measure education poverty[9] has become increasingly pertinent. Learning trajectories provide an opportunity to define education poverty in a way that takes learning dynamics into account and that is informative for policymaking. In a second paper submitted as part of this PhD by Publication, my coauthors and I propose a novel conceptual and empirical definition of education poverty using learning trajectories (Kaffenberger, Pritchett, and Viarengo 2023) (paper 2, Table 1).

Initially, we offer three arguments about education poverty that shape our proposed education poverty standards. First, we argue that measures of schooling alone, such as grade attainment or completion levels, are insufficient as measures of education poverty, similar to the point made in Sustainable Development Goal Target 4.1, which includes measures of both schooling attainment and learning achievement. Learning trajectories are too shallow, and too many children progress from grade to grade lacking even basic skills. A definition of education poverty must therefore include a measure of learning alongside schooling. Second, recognising the dynamic nature of education throughout childhood and young adulthood, with varying learning objectives and the potential for both learning accumulation and deterioration, education poverty should encompass both early and late standards. Third, as with income poverty lines (Jolliffe and Prydz 2016; Ravallion, Datt, and van de Walle 1991), education poverty should include both a low, extreme standard, which represents the educational equivalent to an extreme poverty line which every child should exceed, and a higher 'global' standard, which is a reasonable aspiration for every child but which may not be achieved by some children, even in higher performing countries.

The paper's conceptual contribution lies in combining these to propose two education poverty standards. First is an early/extreme education poverty standard that represents the foundational skills, capabilities, and competencies all children should achieve early in their schooling. This would be measured at about age 8 or 10, typically corresponding to grade 3 or 4. Second is a late/global education poverty standard that children reach later in their schooling and that requires concerted effort even in well-performing countries to ensure children surpass. This would be measured at ages 15 or older, corresponding to grade 10 or 12 and beyond. These align with parts of the SDG Target 4.1 indicators which measure learning in grades 2/3, at the end of primary school, and at the end of lower secondary school, and which measure completion rate of primary education, lower secondary education, and upper secondary education.

[9] In this critical analysis, "poverty" is defined as "a lack of something", and the term "education poverty" specifically refers to "a lack of quality education".

Our empirical contribution involves documenting education poverty levels using both standards and multiple datasets. Table 2 shows analysis of early/extreme education poverty, using UNICEF's MICS numeracy data and DHS literacy data, and late/global education poverty, using PISA and PISA-D mathematics data. In many LMICs, most children fail to reach either the early/extreme or late/global education standard, even if they have attended the appropriate years of schooling.

For the early/extreme standard, for instance, only 1.7% of children in the Central African Republic who have completed grade 6 achieved UNICEF's standard for foundational numeracy.[10] For the late/global standard, PISA and PISA-D assessments reveal that in Paraguay, Senegal, and Zambia, less than 10% of in-school 15-year-olds reach PISA level 2 or higher, considered a minimum proficiency level. Overall, our findings confirm that the overwhelming obstacle to addressing education poverty today is not enrolment or school grade attainment but the shallow pace of learning, preventing children from reaching minimum standards.

Table 2 Education poverty using various assessments

	Early/extreme education poverty				Late/global education poverty			
	Foundational numeracy using UNICEF data[a]		Foundational literacy using DHS data[b]		Mathematics competencies using PISA and PISA-D data[c]			
					Percent above level 1c[c]		Percent level 2 or above[d]	
	Country	Percent	Country	Percent	Country	Percent	Country	Percent
Three highest countries*	Thailand	85.7	Bolivia	100.0	Singapore	99.7	Singapore	92.4
	Kyrgyzstan	67.7	Honduras	100.0	Hong Kong	99.6	Hong Kong	91.0
	Palestine	55.5	Rwanda	97.1	Japan	99.5	Japan	89.3
Average	Average across 18 countries/ regions (un weighted)	39.8	Average across 51 countries (weighted population)	43.9	OECD Non-OECD	98.1 91.8	OECD Non-OECD	76.6 60.0
Three lowest countries**	Togo	14.5	Guinea	4.5	Cambodia	66.2	Paraguay	8.4
	CAR	1.7	Gambia	4.1	Senegal	52.8	Senegal	7.7
	DRC	1.2	Sierra Leone	3.5	Zambia	28.3	Zambia	2.3

Notes: [a] The percent of children who have completed grade 6 who demonstrated basic mathematics proficiency (on grade 2-3 level skills) in the nationally representative UNICEF MICS surveys.
[b] The percent of young adult women who completed grade 6 (and no higher) who could read a single, simple sentence in the nationally representative DHS surveys.
[c] The percent of in-school 15-year-olds scoring above Level 1c on PISA or PISA-D; Level 1c is the lowest achievement level measured on the PISA assessment.
[d] The percent of in-school 15-year-olds scoring Level 2 or above on PISA or PISA-D; Level 2 is the equivalent of reaching Sustainable Development Goal 4 for mathematics proficiency.
, The "highest" and "lowest" countries refer to the related sample of the underlying study (i.e., UNICEF MICS6, DHS, PISA and PISA-D).*
Sources: Silberstein (2021) based on UNICEF MICS6 data for functional numeracy, Pritchett and Sandefur (2017) based on DHS data for literacy, PISA and PISA-D results.

[10] UNICEF's standard for foundational numeracy is below the globally accepted definition of minimum proficiency, indicating that an even smaller proportion of children have reached the global minimum proficiency level.

Our proposal of early/extreme and late/global education poverty standards is similar to measures of income poverty. The World Bank, for instance, uses an extreme poverty line of US$2.15 per day, below which individuals are unable to obtain the minimum level of necessary consumption in poor countries (Ravallion, Datt, and van de Walle 1991). Because simply emerging from extreme poverty is not the aspiration of individuals or countries, however, the World Bank also has a higher poverty line, of US$6.85 per day, which is more relevant in middle income countries (Jolliffe et al. 2022).[11] Similarly, our proposed early/extreme education poverty standard represents a floor, below which no child's or adult's educational achievement should fall, while the late/global standard is a higher but still reasonable aspiration. Furthermore, because education is multidimensional, our proposed measure shares similarities with multidimensional poverty indices, which integrate deprivations across health, education, and standard of living (United Nations 2023). The proposed approach to education poverty focuses on a subset of these dimensions by combining measures of schooling attainment and learning achievement.

3. The role of education in later life outcomes

It is well established that education plays an important role in individuals' later life outcomes. Research on the pecuniary returns to education, for instance, suggest a typical return of 7-10% per year of schooling (Psacharopoulos and Patrinos 2004; Duflo 2001; Peet, Fink, and Fawzi 2015). In terms of non-pecuniary returns, women's schooling has been credited with substantial reductions in child mortality and fertility in LMICs (Gakidou et al. 2010; Cleland and Van Ginneken 1988; Psaki et al. 2019). However, most studies use schooling attainment as a proxy for education without accounting for variation in learning across children per year. Two recent systematic reviews examining causal links between female education and maternal and child health and sexual and reproductive practices highlight the scarcity of studies incorporating measures of learning (Mensch et al. 2019; Psaki et al. 2019). Both reviews acknowledge this as a shortcoming of the current literature.

The next two papers submitted as part of this PhD by Publication contribute to filling this gap by considering the role of learning in later life outcomes. If learning plays a substantial role in outcomes, and children already spend many years in school learning little, improving learning per year could be both an effective and an efficient way to improve children's life outcomes.

3.1 Girls' learning and life outcomes

A third paper submitted as part of this PhD by Publication addresses this gap in the literature by examining the associations between girls' schooling, learning, and later life outcomes in LMICs (Kaffenberger and Pritchett 2021b) (paper 3, Table 1). Given the low average learning levels in

[11] The World Bank has an additional poverty line, of US$3.65, which is most relevant in lower-middle income countries.

LMICs, if even a part of the causal pathway between schooling and outcomes is through learning, existing estimates of the impact of schooling might be underestimating its potential impact. This, in turn, may incorrectly steer investment and policy away from education relative to other priorities. Furthermore, if all or most of the causal pathway is through learning, the returns to improving learning are greater than previously understood.

For our analysis, my coauthor and I draw on two sources of nationally representative household survey data: DHS surveys and FII surveys, each covering multiple LMICs. Each survey employs a common questionnaire across countries and includes measures of schooling attainment, literacy, and outcome variables of interest.[12] For DHS data, we use all available datasets that include the literacy assessment module, which was added to questionnaires in 2000. (some countries have conducted multiple DHS surveys since the literacy assessment was added). In total, we use DHS data from 128 surveys in 54 countries. For FII data, we use the most recent survey, from 2015, for each of the 10 included countries. We refer to each country-year-data source (DHS or FII) combination as one 'survey round', and therefore analyse a total of 138 survey rounds.

We analyse the associations of schooling attainment and literacy achievement with four outcomes: women's fertility, child mortality, and women's empowerment using DHS data, and women's financial behaviours using FII data. We conduct all our analysis at the level of the survey round, running regressions separately for each.[13] We aggregate results using standard random effects meta-analysis weighting methods, such that more precise estimates are given more weight than less precise estimates. Our data is observational, and therefore we do not claim to identify causality. Rather, we aim to exploit existing data that includes measures of both schooling and learning to investigate and signal the potential importance of disentangling schooling and learning in future studies, which could include causal studies.

We first estimate the separate associations between schooling attainment, literacy achievement, and our outcome variables. Utilising equation 3, each outcome (Y_i), observed for each woman (i), is regressed on her years of schooling completed (S_i), her extent of learning (L_i), other control variables (Z_i, which includes age, rural or urban geography, household wealth index), and an error term.

$$Y_i = \beta_0 + \beta_1 S_i + \beta_2 L_i + \beta_3 Z_i + \varepsilon_i \qquad (3)$$

[12] The DHS surveys measure schooling in terms of the highest grade attended. For literacy, respondents attempt to read one simple sentence, and enumerators record their literacy on a three-point scale from "unable to read" to "read the full sentence". The FII surveys measure schooling in terms of levels, including "no formal education", "primary education not complete", "primary education complete" and so on. For literacy, respondents read a three-sentence passage and the enumerator records their literacy on a four-point scale from "unable to read" to "read fluently without help".

[13] We use an instrumental variables approach to address differential measurement error in the schooling and literacy variables; see Kaffenberger and Pritchett (2021b) for more details.

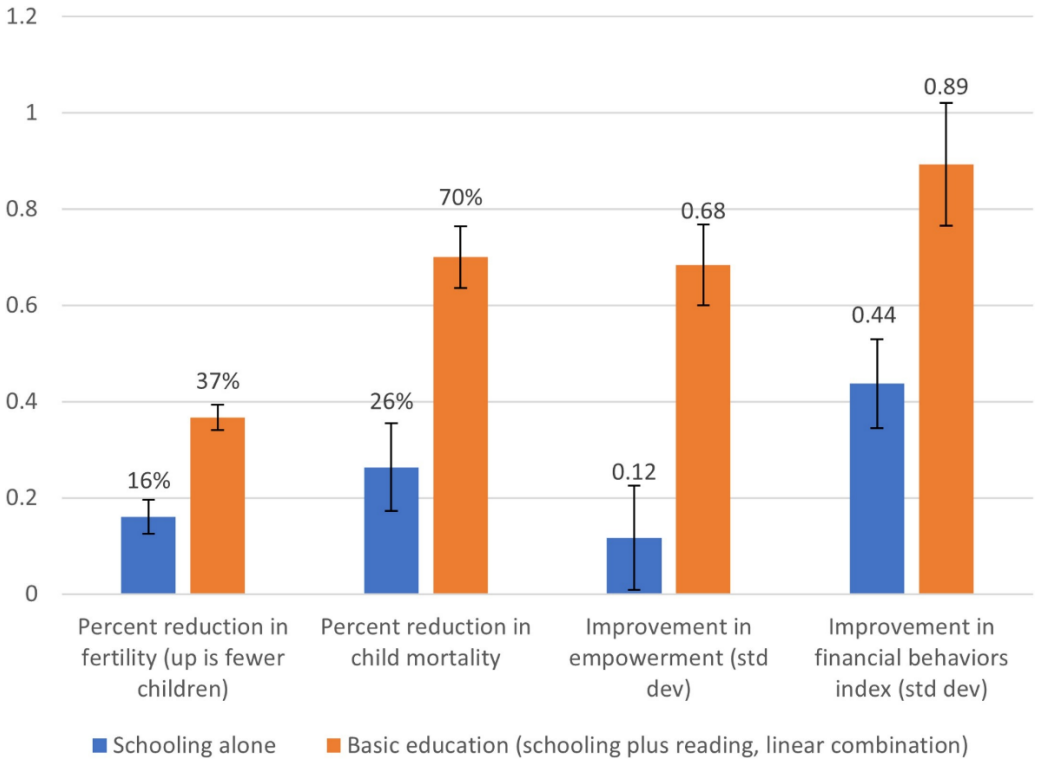
Subsequently, we employ our estimates of β_1 and β_2 from equation 4 to predict the total contribution of basic education (τ_1) to outcomes (equation 4). We define basic education as an individual completing primary schooling (S_i^p) and achieving foundational literacy (L_i^{FL}) (as observed in our datasets). This represents the potential contribution to outcomes that could be achieved if schooling consistently produced a defined level of foundational learning.

$$\tau_1 = \beta_1 * S_i^p + \beta_2 * L_i^{FL} \quad (4)$$

We find that for each of the four outcomes, basic education, which includes both primary schooling and literacy, has a much larger association with life outcomes than primary schooling alone. For fertility, the direct contribution of primary schooling (β_1 scaled to represent primary schooling), which represents a girl completing primary school without achieving foundational literacy, is a -0.54 reduction in total fertility (compared to an average of 3.37 births). This is equivalent to a 16% reduction (Figure 2). The contribution of basic education (τ_1), which represents a girl completing primary school and achieving foundational literacy, is -1.24, equivalent to a 37% reduction in total fertility.

These findings suggest that there are drastic differences in the association of girls' education with a later life outcome when girls are learning little compared with when they are learning more. Similar findings emerge for the other three outcomes.

Figure 2 Associations between girls' primary schooling, basic education, and later life outcomes using scaled coefficients.



Note: Figure shows the random effects weighted average results from IV regressions using 128 rounds of DHS data (fertility, child mortality, and empowerment outcomes) and 10 rounds of FII data (financial behaviors index outcome). "Schooling alone" is the schooling coefficient scaled to represent primary school completion. "Basic education" is the linear combination of the schooling coefficient scaled to represent primary school completion and the literacy coefficient scaled to represent basic literacy. Source: Kaffenberger and Pritchett (2021b).

For child mortality, primary schooling contributes directly with a 2.9 percentage point reduction in the chance of a woman experiencing the death of a child, from an average of 11% (a 26% decline). Basic education, on the other hand, is associated with a 7.7 percentage point reduction, which represents a 70% decline.

Primary schooling corresponds to a 0.12 standard deviation increase in the women's empowerment index, whereas basic education leads to a larger increase of 0.68 standard deviation. Finally, primary schooling is associated with a 0.44 standard deviation increase in the financial behaviours index, and basic education is associated with 0.89 standard deviation.

These findings suggest that a quality education, which includes both schooling and learning, may play a much larger role in women's later life outcomes than schooling by itself. Most existing studies use schooling as a proxy for education. Our findings indicate that such studies likely systematically

underestimate the true association between quality education and later life outcomes, particularly in contexts with low learning outcomes where the association between schooling and learning is weak.

3.2 Learning and schooling persistence

Schooling persistence itself is another outcome to which learning may contribute. Commonly cited reasons that children drop out of school include the inability to afford school fees, books, uniforms, or transportation costs; participation in income earning activities; household work, particularly for girls; pregnancy; and early marriage (Momo et al. 2019; Abuya, Oketch, and Musyoka 2013; Banik and Neogi 2015; Biddlecom et al. 2008). Perceived educational quality has also been found to contribute to dropout (Hanushek, Lavy, and Hitomi 2008; Jensen 2010). Surprisingly, however, learning achievement itself has rarely been considered in analyses of school dropout.

In a fourth paper submitted as part of this PhD by Publication, my coauthors and I investigate the extent to which learning achievement contributes to school persistence and dropout (Kaffenberger, Sobol, and Spindelman 2023) (paper 4, Table 1). We hypothesize that poor learning achievement could contribute to dropout decisions directly, when children or their parents perceive schooling as producing little value. It could also exacerbate other causes of dropout, for instance increasing the attractiveness of outside options and the likelihood that children drop out to join the labour force or that girls dropout to get married (Bedi and Marshall 2002; Zuilkowski, Jukes, and Dubeck 2016). When asked why they dropped out, children often say they dropped out of school to work, but the underlying cause could be the poor quality of education.

This study uses unique, comparable, longitudinal quantitative and qualitative data from Ethiopia, India, Peru, and Vietnam, collected through Young Lives surveys, to investigate the relationship between learning achievement and schooling persistence and dropout. Longitudinal household surveys are rare in LMICs, and those with assessed measures of learning, and linked to qualitative insights, rarer still, making this study a novel contribution to the literature. In our quantitative analysis, we investigate the extent to which learning is associated with school persistence and dropout. Using logistic regressions, we assess whether children's learning at age eight predicts their persistence in school at age 12, and whether learning at age 12 predicts persistence at age 15. We use pooled data and standardised Item Response Theory (IRT) scores developed from the Young Lives mathematics assessment data.[14]

Our qualitative analysis investigates factors which may influence the relationship between learning and school persistence. Young Lives qualitative data collection was conducted with approximately 200 children, parents, caregivers, teachers, health professionals, and community elders in each

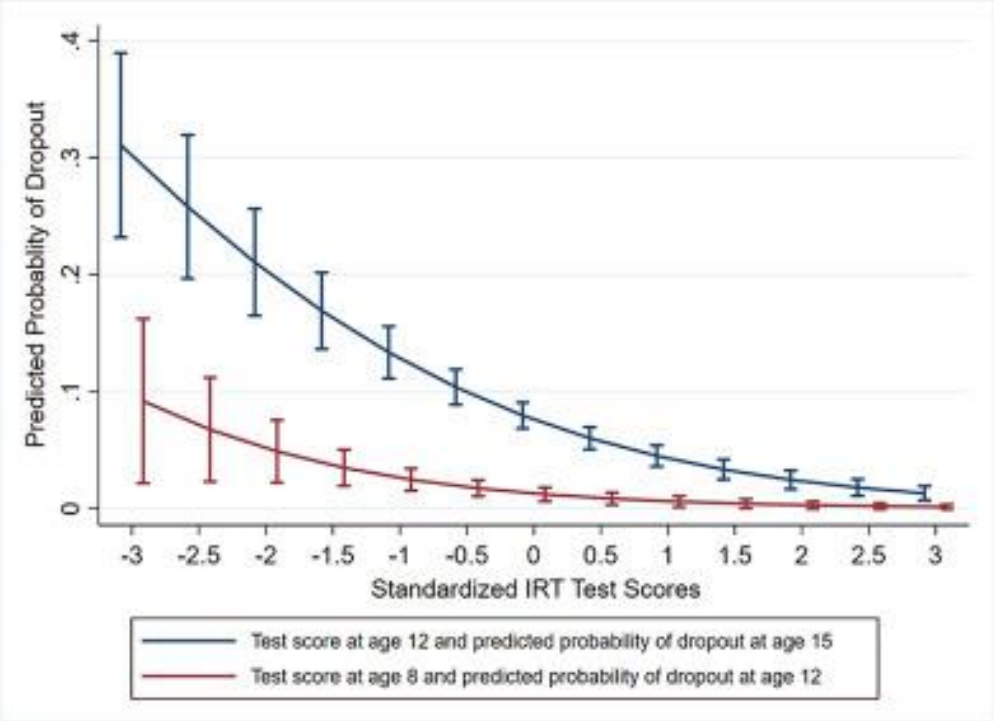
[14] Despite the panel nature of the data, which allows controlling for unobserved time invariant child characteristics, other unobserved variables may still play a role. We use our qualitative analysis to understand factors that may play a role that are unobserved in our quantitative data.

country between 2007 and 2014. Using existing research that has analysed this qualitative data, we identified direct quotes and observations related to learning, schooling, and educational trajectories.[15] We used a deductive approach to develop codes based on our hypotheses, applied these to the sources, and analysed the sources thematically.

The quantitative analysis reveals strong, significant relationships between test scores and subsequent school persistence and dropout (Figure 3). A one standard deviation higher math score at age eight is associated with a 50% reduction in the odds of having dropped out by age 12. Similarly, among children still in school at age 12, a one standard deviation higher math score is associated with about a 50% reduction in the odds of having dropped out by age 15. Said another way, a one standard deviation lower math score is associated with about a 50% increase in the odds of dropping out.

[15] While Young Lives publicly shares quantitative data, they do not have a mechanism for making qualitative data and original transcripts available. We partnered with Young Lives to identify an exhaustive list of publications and reports using Young Lives qualitative data and reviewed 76 papers. Of these thirty-six met our criteria and were included in our analysis.

Figure 3 Predicted probability of dropout by standardised math test score over two time periods.



Note: Figure shows the predicted probability of dropout by age 12 based on standardized test score (mean of zero and standard deviation of 1) at age 8, and again at age 15 based on standardized test score at age 12. Results are based on logistic regressions which control for geography (rural/urban), sex, pre-primary school attendance, a wealth index, household head education, whether the child started school late, and country.

The qualitative analysis suggests multiple pathways through which learning affects schooling decisions. In Vietnam, researchers found that "children's performance and their perception of the value of schooling are the most common" drivers underlying their decision to leave school (Duc and Tam 2013). In Ethiopia, one student stated, "When I evaluated my grades in the past seven grades, I found that I was not able to sit for the next year national examination because we were not taught very well" (Boyden 2013). Students in Peru and Ethiopia reported low learning achievement causing embarrassment and shame, leading them to drop out (MacDonald 2011; Crivello and van der Gaag 2016).

The qualitative findings further suggest early marriage for girls is more likely after a girl drops out of school due to low learning (Young Lives 2016; Tafere and Chuta 2016). In Ethiopia, for instance, parents "are more likely to arrange early marriage for their daughters […] when there are doubts over their potential educational achievements" (Tafere, Abebe, and Assazenew 2009, 11). Poor learning achievement similarly contributes to students leaving school to work. In India and Peru, students

reported that poor learning and anticipation of failing exams led them to drop out and seek income earning activities to better provide for themselves (Vennam, Komanduri, and Roest 2016; Rojas, Guerrero, and Vargas 2016).

These findings point to some of the ways that parents and children consider both outside options and education quality when making schooling decisions. Information on learning outcomes is key for informing such decisions, and trust in institutions also likely plays a role in the decision-making process.

Collectively, the quantitative findings show a significant correlation between learning achievement and schooling persistence, while the qualitative findings suggest that part of this relationship is plausibly causal, even though other unobservable factors cannot be ruled out. The various factors that affect the relationship between learning and schooling detected in the qualitative findings suggest that learning may play a larger role in school persistence and dropout decisions than previously recognised in the literature. This indicates that the returns on improving learning may be larger than previously understood if learning also increases schooling attainment.

4. Modelling education outcomes

Improving learning is a complex process involving many actors, inputs, and dynamic interactions. In the global health field, there is a long history of modelling disease dynamics to inform decision-making. Modelling has been used to estimate disease burden, the need for health interventions (Dodd et al. 2017), costs and benefits of implementing health interventions at scale (Stenberg et al. 2019), and economic outcomes of health policy (Pichon-Riviere et al. 2020). An interdisciplinary field has emerged bringing together empiricists and modellers from disciplines including mathematics, epidemiology, immunology, sociology, and public health to inform public health decision making (Heesterbeek et al. 2015).

In contrast, the education field has typically focused on reduced-form education production functions to estimate relationships between education inputs and outcomes (Bowles 1970; Hanushek 2020). Extensive literature has examined the impact on educational outcomes of programmes such as cash transfers, scholarships, information-based interventions, school construction, improving teacher attendance, increasing provision of material inputs, and remedial instruction (Glewwe, Lambert, and Chen 2020; Glewwe and Muralidharan 2016; Ganimian and Murnane 2016).

While this literature provides precise, reduced form estimates of educational outcomes from specific programmes, it has two key shortcomings. First, it does not enable modelling of the dynamic interactions that drive educational outcomes, in contrast with global health where health and disease dynamics are part of the modelling. Second, it does not typically ‘look inside’ a key part of the

production function, namely pedagogy and within-classroom teaching and learning dynamics that affect educational outcomes. While cognitive science literature does include work on modelling, such as of brain functioning simulations, a review of this body of work falls outside the scope of this critical analysis.

4.1. A structural model for learning

In a fifth paper submitted as part of this PhD by Publication, my coauthor and I contribute to filling this gap in the literature by developing a structural model of the learning process, which we call a 'Pedagogical Production Function' (PPF) (Kaffenberger and Pritchett 2021a) (paper 5, Table 1). We then use our parameterised model of the learning process to simulate educational outcomes under different policy approaches.

To inform our model's parameters, we first synthesise empirical literature on learning outcomes, learning trajectories, and programmatic and policy approaches that have been shown to improve learning, with three key implications for the model. First, learning varies tremendously across countries and these differences emerge early in the schooling progression (Singh 2020; Pritchett and Sandefur 2020; Hanushek and Woessmann 2008), necessitating a model capable of accommodating large variation in per-year gains. Second, learning varies substantially within countries (Spaull and Kotze 2015; Beatty et al. 2021; Bau, Das, and Yi Chang 2021), indicating the need for a model that allows for variation across the distribution of children's learning achievement within countries. Third, there is often a mismatch between curriculum, instruction, and the typical child's learning level, frequently referred to as 'overambitious curriculum', and better alignment typically improves learning (Muralidharan and Singh 2021; Pritchett and Beatty 2015; Banerjee et al. 2017; Piper et al. 2018). The need for alignment between instruction and children's learning levels is further reflected in psychology and education literature, suggesting that children learn best when instruction is focused on their 'zone of proximal development' (Vygotsky 1978).[16]

Based on this synthesis, we define a set of six parameters to formally characterise the learning process. The first parameter is the shape of the PPF, which is assumed to be trapezoidal, allowing for variation in learning across the student distribution each year (equation 5 and visualised in Figure 4). The second is width (w), which gives the range of student learning levels that learn anything under the PPF. Students whose learning level is outside the range (either too high or too low) are assumed to have learning gains of zero. The third parameter is height (h), with the maximum and minimum

[16] The zone of proximal development is typically defined as tasks that a learner can do only with assistance or guidance. This includes tasks that are more difficult than what the learner can do on their own, but not so difficult that they are cognitively impossible for the learner (at their current stage of education) even with assistance or guidance.

heights determining the most and least that is learned by children within the range of the PPF. The fourth is slope (*r*), which connects the maximum and minimum heights and determines the variation in learning gained within a single year (steeper slopes produced greater variation across students who learn). The fifth parameter is the center (π^G), which is the learning level the PPF is centered on. This can be thought of as the student learning level that the curriculum and instruction are pitched to. Last is the pace parameter (*p*) which indicates the extent to which the PPF shifts up, towards higher learning levels, with each grade level progression.[17]

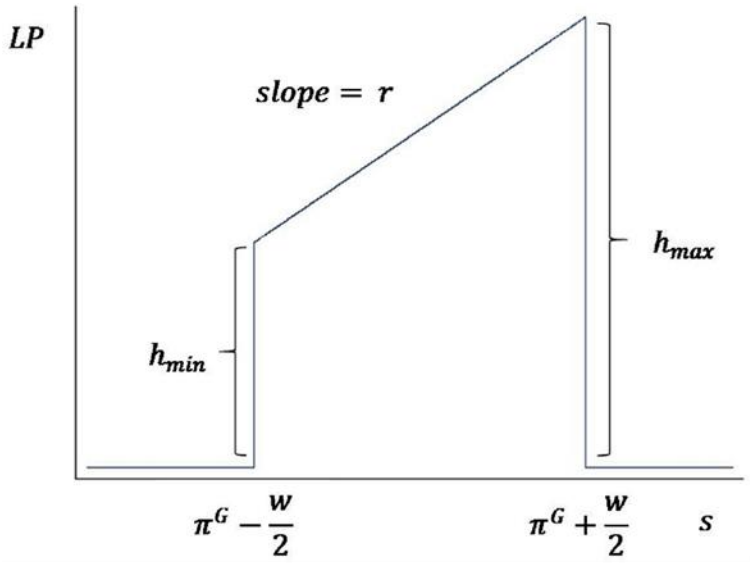
These parameters (except pace, discussed separately) come together in equation 5, and are illustrated in Figure 4:

$$PPF(LP(w,h,r,\pi^G),s^i) = \begin{cases} 0 \quad if\ s^i < \pi^G - \frac{w}{2} \\ h_{min} + r\left(s^i - (\pi^G - \frac{w}{2})\right) \quad if\ \pi^G - \frac{w}{2} < s^i < \pi^G + \frac{w}{2} \\ 0 \quad if\ s^i > \pi^G + \frac{w}{2} \end{cases} \quad (5)$$

The PPF represents, on average, what a child *i* with student learning level *s* would learn if they attended grade *G*. In equation 5, the learning in grade *G* of student *i* of initial learning level *s* is a function of the width *w*, height *h*, slope *r*, and center π^G of the trapezoid.

[17] The pace here is best interpreted as the prescribed pace in the standardised curriculum that teachers are required to follow in their instruction. It determines how many topics and subtopics must be covered in each schooling period, thus determining the speed teachers must maintain to cover all the required material. The pace may be slowed, for instance, by reducing the number of required topics and thus allowing more instructional time for each remaining topic (see, for instance, Rodriguez-Segura and Mbiti (2022)).

Figure 4 Pedagogical production function for modelling the learning process.



Note: The Y axis is the learning produced by the PPF and the X axis is cumulative student learning achievement using the same scale. Source: Kaffenberger and Pritchett (2021a)

The pace parameter, *p*, represents the shift in the PPF from one grade to the next, as the level of instruction shifts to the next grade level. To model learning, we apply the PPF to an initial distribution of student learning levels; this produces a new distribution of student learning levels, representing the distribution after one year of school. Using the pace parameter, we then shift the PPF to the right, and apply it to the new distribution to represent the subsequent school year. As the PPF shifts, some students may fall outside its range and cease learning new content due to learning less than the pace assumes.

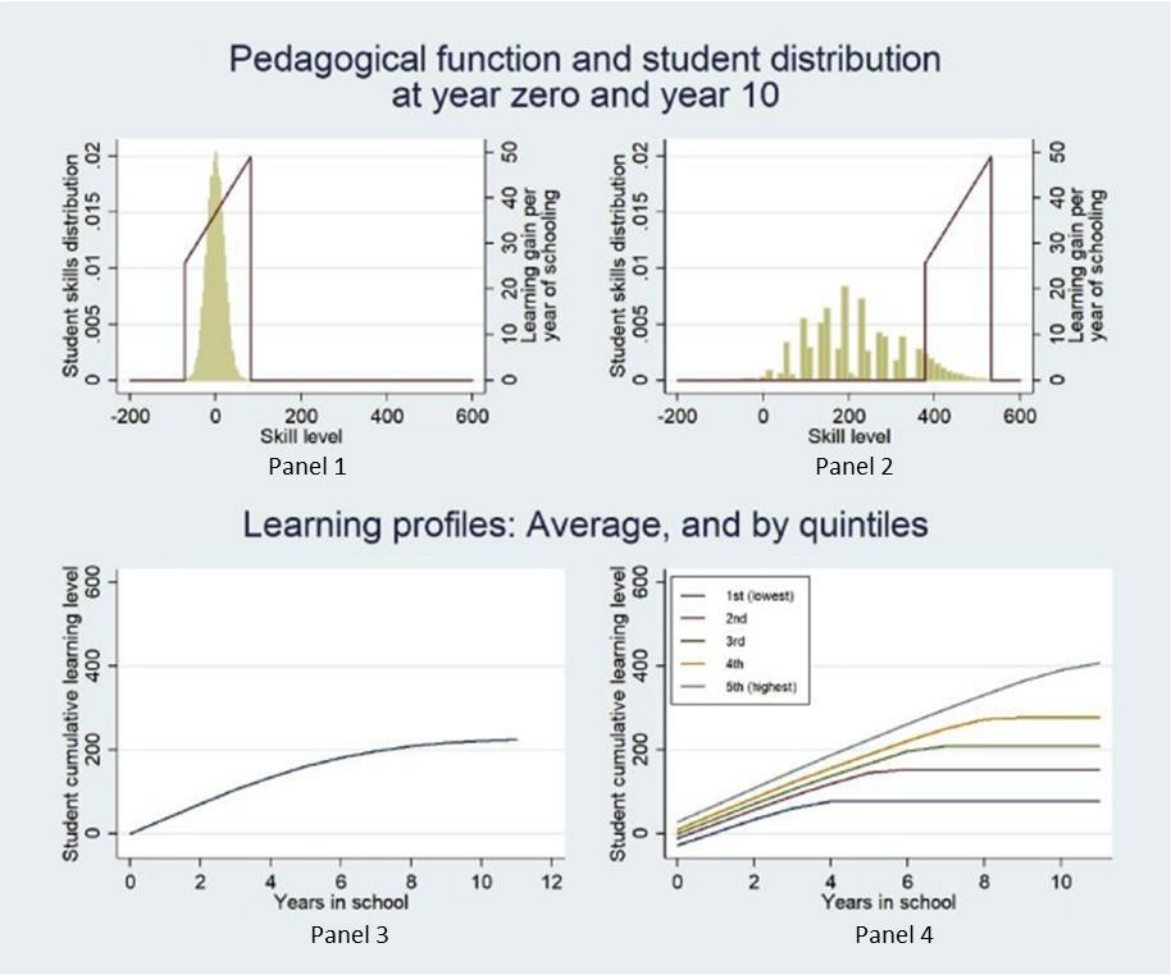
We first calibrate the parameterised model to reproduce observed learning outcomes. We assume an initial normal distribution of children's learning levels, centered on zero as they enter grade 1. We also assume that the grade 1 PPF is centered on this distribution, and that in grade 1 all children are within the PPF range (Figure 5, panel 1). We calibrate the model to replicate the average grade 10 learning distribution in mathematics across seven LMICs that participated in the PISA-D assessment.[18,19]

[18] PISA scores are standardised so that the mean score of participating children (who are 15 years old, in school, and on average in grade 10) is 500 and the standard deviation is 100. PISA-D uses the same scale, while covering a lower-income, lower-performing set of countries. For PISA-D, the average score was 324 with a standard deviation of 74. We calibrated the model so that the portion of the student distribution which is in-school in grade 10 reflects the PISA-D results. We assume lower performing students drop out first.

[19] We calibrated our model to PISA-D learning outcomes because of the availability of comparable learning outcomes data across multiple developing countries on a standardised scale. PISA-D is just one option, and in future work the model could be calibrated to alternative learning outcomes data. Details on the calibration process are available in Kaffenberger and Pritchett (2021a). In future work we seek to incorporate additional

Figure 5, panel 2, shows the distribution of children's learning levels at the end of grade 10 produced using the calibrated PPF. These calibration results show that by grade 10, the majority of children are outside the range of the PPF and not learning. Figure 5, panels 3 and 4 show the average learning trajectory and learning trajectories by initial learning quintile,[20] respectively, produced by the calibrated model. The learning trajectory of the bottom quintile of learners is flat after grade 4 (Figure 5, panel 4).

Figure 5 Student learning distributions and PPF in grade 1 and 10 and learning trajectories using the calibrated PPF model.



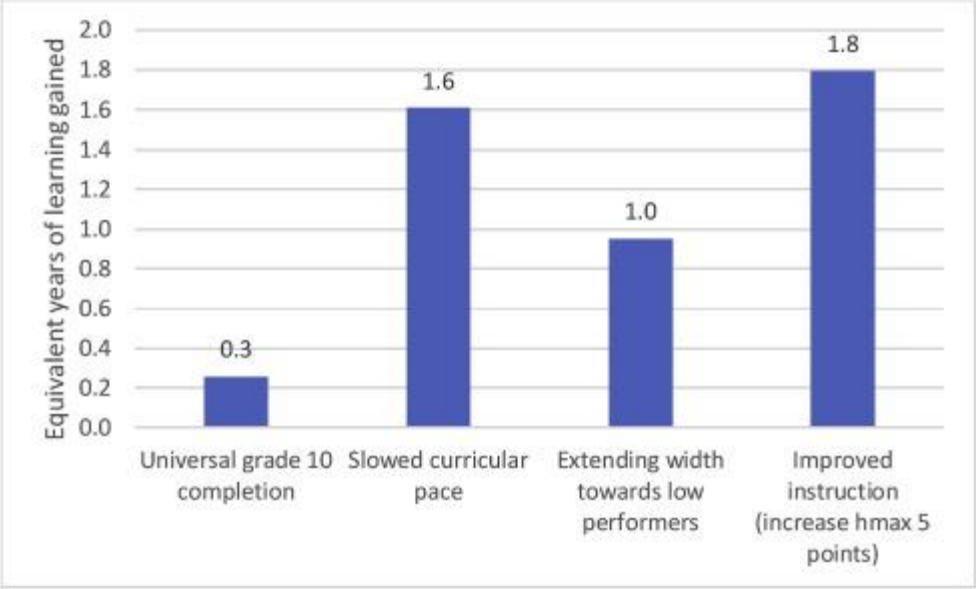
Source: Kaffenberger and Pritchett (2021a)

data sources into the calibration process to continually improve and advance the model's ability to represent education system dynamics.

[20] The terms 'learning trajectories' and 'learning profiles' are used interchangeably.

We use this calibrated model to analyse four counterfactual policy scenarios.[21] We first simulate expanding schooling completion to reach universal completion of grade 10. This simulation represents a 70 percentage-point increase in grade 10 completion, from the current completion rate of 30%. The model suggests that this large increase in schooling attainment would produce only limited learning gains: it would increase average grade 10 learning by 9.2 points on the PISA scale,[22] representing the learning equivalent of 0.25 years of school in PISA-D countries (Figure 6). The small magnitude of the gains stems from many of the children being outside the range of the PPF, which implies they could not engage in the learning process despite the additional years in school.

Figure 6 Summary of simulated learning gains, in terms of learning-equivalent years of schooling, for various policy scenarios.



Source: Kaffenberger and Pritchett (2021a)

The second counterfactual scenario involves slowing the PPF pace, equivalent to reducing the pace of instruction or curriculum, to better align with the average pace of children's learning. Overambitious curriculum, which moves faster than the typical pace of learning, causes children to fall outside the range of the PPF. Therefore, somewhat counterintuitively, slowing the pace could increase overall learning, as more children can keep up with the level of instruction for longer. Using the calibrated model to simulate a slower pace yields average grade 10 learning that is 58 points higher on the PISA scale, equivalent to an increase of 1.6 years' worth of learning (Figure 6).

[21] We model these counterfactuals as distinct policy scenarios to provide a first benchmark; as policies are often designed and implemented as integrated programmes, future work will benefit from modelling feasible combinations of policy approaches.
[22] The PISA scale has mean 500, standard deviation of 100 among grade 10 students.

A third scenario simulates expanding the range of instruction by increasing the width to encompass more of the left tail of the learning distribution. Implementing such a strategy would require equipping teachers to better instruct lower performing children while maintaining a similar level of instruction for the rest of the student distribution. This scenario increases average grade 10 learning by 34 points, the equivalent of nearly one year's worth of schooling.

Finally, a fourth scenario simulates raising the height of the PPF, representing increasing the quality of teacher instruction so that all children within the PPF range learn more each year. This scenario increases average grade 10 learning by 64 points, the equivalent of 1.8 years' worth of schooling.

While increasing PPF height – equivalent to improving the quality of teacher instruction – demonstrates the most substantial simulated impact on student learning, it is also likely to be one of the harder scenarios to implement. In-service teacher training has proven notoriously difficult to implement effectively in LMICs (Popova et al. 2022). Slowing the pace of instruction and curriculum and extending the PPF width so that lower performing children receive effective instruction, mirror two proven approaches to improving learning: structured pedagogy and teaching at the right level, both of which target instruction to children's learning levels better than typical standardised curriculum (Piper et al. 2018; Banerjee et al. 2017).

On a broader level, this parameterised model has potential for simulating policy approaches in numerous contexts. While this study calibrates the model to PISA-D data, it could be calibrated to other data sources, including country-specific data sources. Country-specific calibrations could take into account contextual factors that were beyond the scope of the current modelling exercise.

Additionally, there are many factors that affect children's learning that are not represented in the current set of parameters. These include education-specific elements such as textbook availability, language of instruction and alignment with home language, and teacher training, as well as broader influences like poverty, health, literacy environment, and self-belief. The lack of sufficient data makes it challenging to incorporate many of these factors into a quantitative model. Future work will aim to explore additional data sources and methods for integrating these factors into the modelling parameters.

Other policy scenarios could also be simulated, such as simulating changes to PPF slope (to increase or reduce student learning variation) or simulating different groupings of children so each receives instruction tailored to their learning level. Future work could also further refine data needs and availability for each parameter and incorporate additional findings from causal evidence of effective

interventions. Future work will also benefit from incorporating the costs of reform efforts into the modelling to enable consideration of budgetary implications.[23]

4.2. Applications of the pedagogical production function

The Covid-19 pandemic presented an acute education policy situation for which the model developed in Kaffenberger and Pritchett (2021a) was well suited. In a sixth paper submitted as part of this PhD by Publication, I apply the parameterised, calibrated PPF model to estimate learning losses and the potential impact of recovery policies (Kaffenberger 2021) (paper 6, Table 1). This paper provided the first estimates for LMICs of the potential long-term learning losses resulting from the Covid-19 pandemic-related school closures, providing a novel and practical application of the PPF modelling methodology.

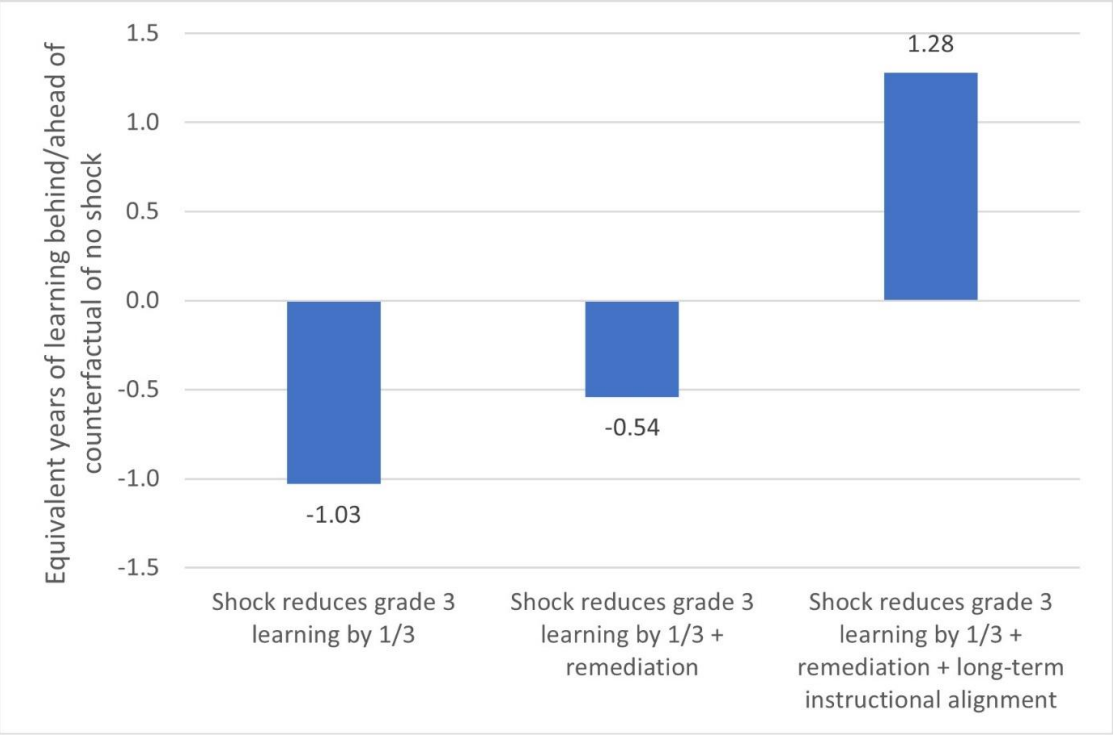
Increasing evidence indicates significant learning losses among children during Covid-19 school closures. In South Africa, for instance, primary school students lost between half to three-quarters of a year of learning (Ardington, Wills, and Kotze 2021). A review found that, on average across 36 'robust studies', children lost about half a year's worth of learning during school closures (Patrinos, Vegas, and Carter-Rau 2023). These studies, however, focus on immediate learning losses accrued during school closures, with losses typically measured around the time children return to school. Missing from this body of work are estimates of the potential long-term implications of these short-term losses.

My sixth paper contributes to filling this gap by modelling potential long-term losses and the long-term outcomes of different remediation approaches. Children who experienced learning losses during school closures re-entered school significantly behind the level of instruction than they otherwise would have been, potentially placing them on a long-term, shallower learning trajectory without adequate remediation. Therefore, the gap between their actual learning achievement and the counterfactual learning achievement without the pandemic could continue to grow even after their return to school.

Using the same calibrated PPF model as in Kaffenberger and Pritchett (2021a), I introduce a learning loss shock for children in grade 3 and simulate how their learning is affected through grade 10. Assuming children missed out on one-third of a year's worth of learning during closures – a conservative assumption according to empirical evidence[24] - with no remediation upon their return to school, learning losses are found to grow even after children return to school, with an average deficit of one year's worth of learning by grade 10 (Figure 7).

[23] Incorporating costing was, unfortunately, not possible and beyond the scope of the current analysis.
[24] This is a conservative assumption, and more recent empirical findings suggests learning losses were larger (e.g., Patrinos, Vegas, and Carter-Rau (2023)).

Figure 7 Modelling long-term Covid-19 learning loss and mitigation strategies.



Source: Kaffenberger (2021)

The paper then considers two remediation approaches. First, I model a short-term remediation approach. This assumes teachers cover one-third of the grade 3 curriculum upon children's return to school before advancing to grade 4 topics. From grade 5 onwards, instruction reverts to pre-pandemic levels and pace. This short-term remediation reduces the long-term learning losses by half, with affected children lagging about half a year's worth of learning behind by grade 10 compared to their uninterrupted trajectory (Figure 7).

The second remediation scenario models the potential outcomes if countries capitalise on the disruption caused by Covid-19 and subsequent learning recovery efforts to implement a long-term reform strategy. This scenario assumes that remediation occurs when children return to school, as in the first scenario, and that subsequently, the level and pace of curriculum and instruction remain aligned with children's learning levels.[25] It assumes education systems equip and empower teachers to implement effective strategies, such as adapting their instruction to children's learning levels and ensuring children achieve foundational skills needed for later learning, initially for the purposes of remediation, and then as part of a sustained effort to maintain effective instructional approaches.

[25] I used the optimised PPF pace from Kaffenberger and Pritchett (2021a), which implies better alignment between instructional pace and children's levels and pace of learning.

Using the model, this scenario is found to fully mitigate the Covid-19 related learning losses and increase grade 10 learning above the counterfactual of no disruption by more than a full year's worth of learning. As in Kaffenberger and Pritchett (2021a), aligning the pace of instruction with the pace of children's learning produces large simulated gains.

Subsequent to this study being published, evidence has emerged on learning losses and remediation approaches related to Covid-19 school closures, with mixed results. Assessments conducted by UNESCO in 2021 found no statistically significant declines in the proportion of children reaching established Minimum Proficiency Levels (MPLs) in Burkina Faso, Burundi, Cote d'Ivoire, Kenya, Senegal, and Zambia, though the assessments were not able to detect losses below the established MPLs (UNESCO Institute of Statistics 2022). In Tamil Nadu, India, on the other hand, remediation was found to support a partial recovery of the learning lost during school closures in line with what the model predicts (Singh, Romero, and Muralidharan 2024).[26] Updating the above model based on evidence from post-Covid-19 learning assessments and remediation efforts would be an intriguing direction for future work.

5. Systems thinking in education

There is increasing focus in international education on systems thinking and systems change to improve learning outcomes, stemming from several origins. First, a wealth of evidence shows that isolated educational inputs do not typically improve learning (Glewwe, Kremer, and Moulin 2009; de Ree et al. 2018; Mbiti et al. 2019; Rodriguez-Segura 2022), suggesting that piecemeal approaches are insufficient for improving outcomes.

Second, evidence shows that approaches that do improve learning typically adopt an integrated approach, improving multiple elements in an education system simultaneously. For instance, structured pedagogy and teaching at the right level, which have strong evidence for improving learning, incorporate multifaceted approaches, including improved sequencing and scope of learning topics, teaching and learning materials, teacher training and support, and more (Piper et al. 2018; Banerjee et al. 2017; Global Education Evidence Advisory Panel 2023). This suggests that addressing multiple system constraints at once may be key for improving learning outcomes.

Finally, there is a recognition that the growth in education systems in LMICs over the last 70 years primarily focused on rapid expansion in schooling attainment (Barro and Lee 2013). Rapid schooling expansion has often been tied to goals of nation building, with less emphasis on education quality (Reimers 2020; Paglayan 2022; Opalo 2022). Many education systems today are oriented for and have

[26] Note that in some contexts remediation may not be feasible, for instance due to budgetary or other constraints.

the infrastructure, personnel, and accountability structures to ensure widespread schooling but not widespread learning.

Considerable progress has been made in systems thinking in education. A recent book edited by Faul and Savage (2023), and including contributions from more than 25 researchers, practitioners, and funders, highlights a growing effort to analyse education systems and address system-level constraints to learning.[27] Initiatives such as the Research on Improving Systems of Education (RISE) Programme, a seven year research endeavor funded by the United Kingdom's Foreign, Commonwealth, and Development Office (FCDO), has been on the forefront of education systems research, arguing that achieving system coherence for learning is critical for lasting improvements (Pritchett 2013). Education systems change is also a core part of major multilateral organisations' focus (Global Partnership for Education 2022; United Nations 2022).

A key principle in education systems thinking and in the education systems change literature is that of system coherence, which refers to the alignment of system components towards achieving a set of common goals (Pritchett 2015; Levy 2022; Crouch and DeStefano 2017). Systems can be coherent for different outcomes. For instance, education systems can be coherent for schooling expansion, as in LMICs during their rapid expansions in the latter half of the 20th century. Education systems can also simply be incoherent for achieving outcomes (Levy 2022). The three papers reviewed in this section contribute to refining the hypothesis that improving education system coherence for learning is key for improving learning outcomes.

5.1. System coherence and instructional alignment

In most education systems, curriculum standards prescribe the content students should learn, and classroom instruction, teacher training, teaching and learning materials, assessments, and examinations are expected to align with the standards (Porter 2002; McMillan 2008). This alignment of instructional elements is considered crucial to student learning (City et al. 2009; Elmore 2010; Crouch 2020). Alignment, however, is often assumed rather than verified. Formal analysis of the content, progression, and alignment of curriculum standards, exams, and teacher instruction remains rare (Burdett 2017; Polikoff 2012).

In the seventh paper submitted as part of this PhD by Publication, my coauthor and I use a novel methodology, the Surveys of Enacted Curriculum (SEC), to systematically analyse and empirically quantify instructional alignment in the Uganda and Tanzania education systems (Atuhurra and Kaffenberger 2022) (paper 7, Table 1). Most analysis of education system alignment uses qualitative methods, such as case studies, ethnographic approaches, or education system diagnostics (Crouch

[27] One of the papers reviewed in this section is a chapter in this book.

2020; Aiyar et al. 2021). SEC introduces a key innovation to this literature by quantifying alignment and misalignment.

The SEC methodology has been used in the United States for more than 20 years to analyse alignment between state-level curriculum, national standards, and teacher classroom instruction (Blank, Porter, and Smithson 2001; Porter 2002; Polikoff 2012). Our paper represents the first application in LMIC contexts.

We adapted the SEC approach to quantify the content and alignment of primary curriculum standards, national primary leaving exams, and teacher classroom instruction for English and mathematics in Uganda and Tanzania. In both Uganda and Tanzania, curriculum standards and national exams are set by separate agencies, which hinders content alignment (Ward, Penny, and Read 2006; MoEST 2018).[28] Schools and teachers are expected to both complete the prescribed curriculum and prepare children for national exams, and when the content of these are poorly aligned, teachers face an incoherent mandate.

To conduct the study, a team of in-country experts was recruited in each country to develop a taxonomy of topics and subtopics for English and mathematics, tailored to each country's context. The experts also adapted a set of five cognitive demand levels, based on Bloom's taxonomy (Anderson and Krathwohl 2001), to each country's context. They then coded and rated the competencies in the curriculum standards and items on the national primary leaving exams using the taxonomy and levels of cognitive demand. Teacher instructional content was measured through surveying a purposive sample of teachers selected from rural and urban districts in each country, using the same structure as that for curriculum and exams.

The result of this process is a dataset for each of the curriculum standards, national primary leaving exams, and teacher instructional coverage that includes the percentage of total emphasis that goes towards each topic and cognitive demand combination. The SEC methodology then allows quantifying alignment across components on a zero to one scale, with zero indicating no overlap in content, and one indicating complete overlap. A score of 0.5 is considered reasonably well aligned across components.[29] The results are visualised with three-dimensional descriptive content maps. In this review, due to space constraints, I focus on results for English in Uganda and Tanzania. Results for mathematics are available in Atuhurra and Kaffenberger (2022).

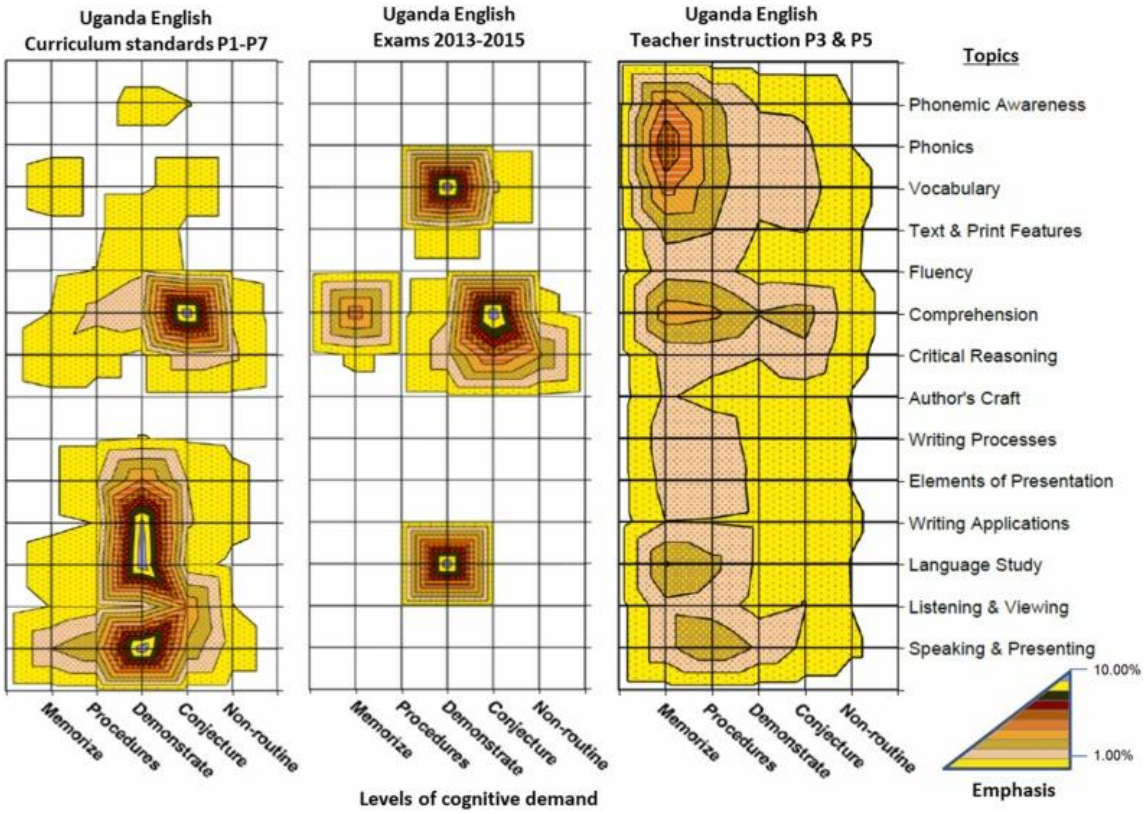
[28] In Uganda, curriculum standards are set by the National Curriculum Development Centre (NCDC) and exams by the Uganda National Examinations Board (UNEB) (Government of Uganda 1973; 1983). In Tanzania, the respective bodies are the Tanzanian Institute of Education (TIE) and the National Examinations Council of Tanzania (NECTA) (Government of Tanzania 1975; 2019; MoEST 2018).

[29] Perfect alignment is not the goal. Exams cover a subset of the total content students are expected to learn, and teachers adapt their instruction to meet the realities of their classroom. The target level of alignment is informed by context, with 0.5 serving as a reasonable rule-of-thumb.

In Uganda, the English curriculum standards focus on a relatively narrow set of topics, placing two-thirds of their emphasis on just three content topics: comprehension, language study, and speaking and presenting (Figure 8, panel 1). Most prescribed coverage is at middle levels of cognitive demand, expecting students to be able to analyse and demonstrate understanding. National exams cover an even narrower set of content, focused on vocabulary, comprehension, and language study at middle levels of cognitive demand (Figure 8, panel 2). Teachers, however, spread their coverage across all 14 topics (Figure 8, panel 3), with a preference for lower cognitive demand levels, emphasising memorisation.

When quantifying alignment, we find that English curriculum standards and national exams in Uganda have an alignment score of 0.36, falling below the 0.5 threshold. This is driven in part because two high-emphasis topics from the curriculum standards are completely absent from the exams (writing applications and speaking and presenting). Comparing teacher instruction with the curriculum standards yields an alignment score of just 0.15, indicating very little overlap. The visualisations in Figure 8 vividly illustrate this low alignment.

Figure 8 Ugandan English: Content and alignment of curriculum standards, national exams, and teacher instruction.



Note: Visualizations represent 3-dimensional content maps. Instructional topics are on the Y axis, levels of cognitive demand on the X axis, and level of emphasis on the Z axis (displayed using colour intensity). The panels show Ugandan English curriculum standards aggregated for grades 1–7 (Panel 1), aggregate Ugandan English primary leaving exams from 2013 to 2015 (Panel 2), and Ugandan English teacher instruction aggregated for grades 3 and 5 (Panel 3). Source: Atuhurra and Kaffenberger (2022)

In Tanzania, content from three topics dominates the English curriculum standards, accounting for 80% of total coverage: comprehension, language study, and presenting (Figure 9, panel 1). More than half the cognitive demand emphasis is on explain, with the remaining emphasis divided between recall and generate.[30] The national exams focus on just three topics, vocabulary, comprehension, and language study, and the lowest levels of cognitive demand, recall and explain (Figure 9, panel 2).

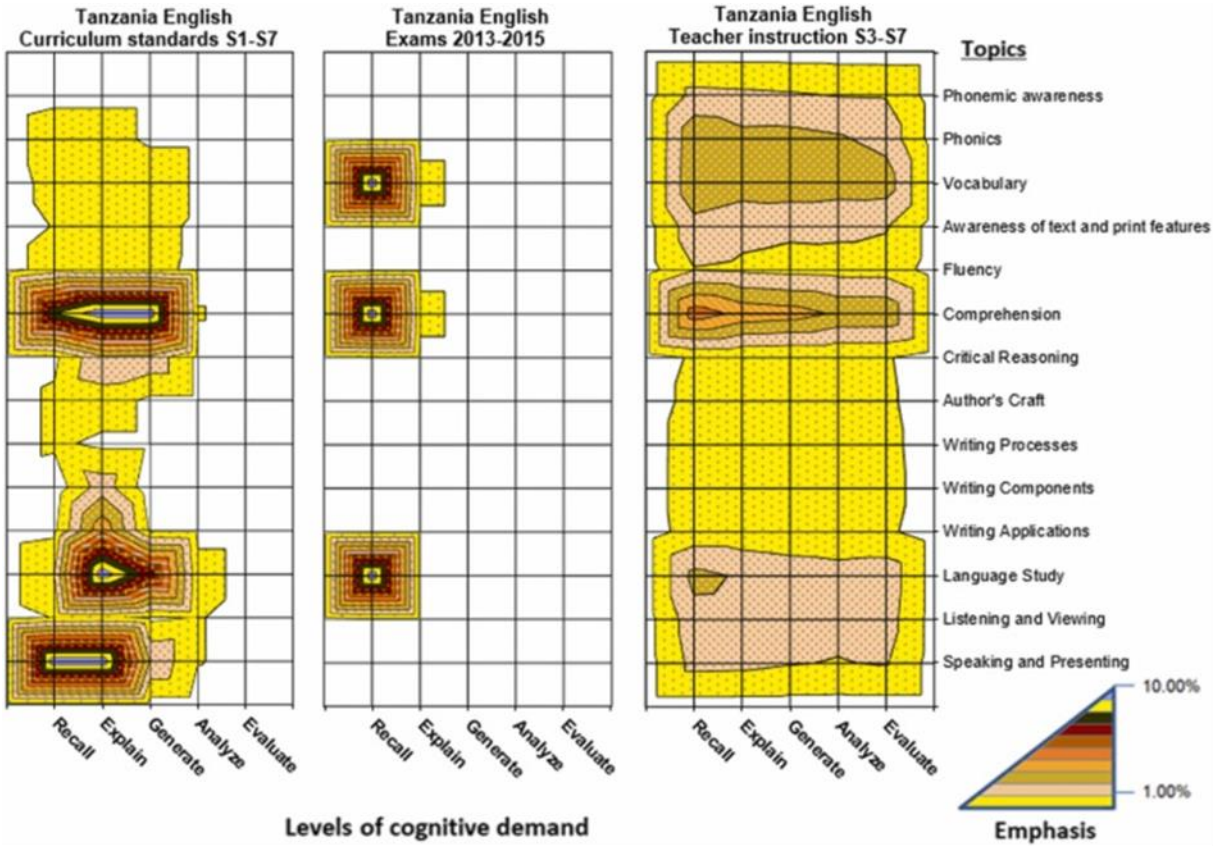
While teachers cover similar topics as those prescribed in the curriculum standards, they do so at varying levels of cognitive demand and emphasis (Figure 9, panel 3). Notably, two topics receive

[30] Because of country-specific adaptations, English in Tanzania uses different labels for the levels of cognitive demand, but they refer to the same scale.

70% of the content coverage in the curriculum standards, but receive only 28% of teachers' instruction coverage.

The English curriculum standards and national exams have an alignment score of just 0.11 in Tanzania, indicating very little overlap in content coverage. The second most-emphasised topic in the curriculum standards, speaking and presenting, is absent from the exams. Teacher instruction and curriculum standards have an alignment score of 0.32, while teacher instruction and national exams have an alignment score of just 0.12.

Figure 9 Tanzanian English: Content and alignment of curriculum standards, national exams, and teacher instruction.



Note: Visualizations represent 3-dimensional content maps. Instructional topics are on the Y axis, levels of cognitive demand on the X axis, and level of emphasis on the Z axis. The panels show Tanzanian English curriculum standards aggregated for grades 1–7 (Panel 1), aggregate Tanzanian English primary leaving exams from 2013 to 2015 (Panel 2), and Tanzanian English teacher instruction aggregated for grades 3–7 (Panel 3). Source: Atuhurra and Kaffenberger (2022)

The study presents three primary findings. First, in both countries the curriculum standards demonstrate room for improvement. English standards offer limited emphasis on or completely omit foundational reading skills such as phonemic awareness, phonics, and vocabulary, in both contexts.

Second, the poor alignment between curriculum standards and primary leaving exams burdens teachers with the challenging task of determining priorities for instructional time allocation. Third, rather than aligning closely with either the curriculum standards or exams, teachers cover broad swathes of content. This may be a result of insufficient training or reflect resistance to content that is poorly structured for student learning.

The study illustrates the potential the SEC methodology holds for advancing our understanding of instructional alignment and informing policy making. Since our study, SEC has been used in Nepal to evaluate implementation of a new literacy curriculum, and in Nigeria, to understand alignment of curriculum, exams, teachers' instruction, and the pace of children's learning (Atuhurra et al. 2023; Adeniran et al. 2023).

5.2. Education system coherence in reform settings

In the eighth paper submitted as part of this PhD by Publication, my coauthor and I take a broader view of system coherence and study it in the context of a reform package in Sobral, Brazil, and a nationwide teacher reform in Indonesia (Kaffenberger and Spivack 2023) (paper 8, Table 1). These two reforms were selected because of their divergent outcomes: while Sobral, Brazil succeeded in improving children's learning achievements, the reform in Indonesia failed to yield any impact on children's learning. The study uses an education systems framework and diagnostic approach to explore the role of system coherence in these reform outcomes, and serves as an early assessment of the usefulness of framework for examining existing and planned policies.

The education systems framework that we use is rooted in an established framework for public service provision (Moore 1995; World Bank 2004) and expanded for education as described in Pritchett (2015). The framework identifies four types of relationships, centered around accountability between principals and agents, and five elements across which actors in those relationships interact. The framework provides the structure for our analysis.

In the framework, the 'politics' relationship represents how citizens interact with the highest government authorities (e.g., president's or prime minister's office). The 'compact' relationship represents how these government authorities interact with education authorities (e.g., the education ministry). The 'management' relationship represents how the education authorities interact with frontline education workers (e.g., school leaders and teachers). Finally, 'voice and choice' represents how parents, children, and communities interact with frontline education workers.[31] The five elements through which the actors interact are 'delegation', 'finance', 'information', 'motivation', and 'support'. The relationships and elements are displayed as columns and rows respectively in the

[31] Parents, for instance, play a key role in the educational outcomes of their children; a detailed analysis of these dynamics is unfortunately beyond the scope of this critical analysis.

matrix in Figure 10. Embedded in this framework is a hypothesis that low learning outcomes stem from incoherence for learning in the relationships and elements, and that learning improvements result from greater coherence for learning. We use the framework to examine the reforms in Brazil and Indonesia.

Sobral, a relatively poor municipality in Brazil, undertook substantial educational reforms between 2005 and 2017, and subsequently rose from being the 1,366th ranked municipality in Brazil's national basic education assessment to being the top performer (Crouch 2020). By 2017, its test scores exceeded by 80% what would be expected for its level of education expenditure relative to other municipalities in Brazil.

To assess the extent to which Sobral's reform improved system coherence for learning, we mapped the reform to the education systems framework. The results are shown in Figure 10. Each cell that was addressed through the reform contains a short description of how it was addressed; empty cells were not addressed. In the delegation row, we find that within the compact relationship Sobral's mayor committed the education system to achieving clear learning goals – specifically, universal literacy by grade 2 (A, Figure 10) (Loureiro and Cruz 2020; Crouch 2020). Within the management relationship, the Education Secretariat relayed those goals to schools and teachers (B, Figure 10). Within the voice and choice relationship, regular dialogue with policymakers led parents to reinforce the goals with schools and children (C, Figure 10).[32]

[32] Although many parents initially opposed the reform package, this regular dialogue persuaded them to support the reform.

Figure 10 Mapping of elements of Sobral, Brazil reform package to the education systems framework.

Five design elements	Principal–agent relationships of accountability			
	Politics	Compact	Management	Voice & Choice
Delegation		A. Mayor delegates explicit learning goals, including universal literacy in first two years of primary and remediation for children in older grades, with the slogan of 'Alphabetization (literacy) at the Right Age'	B. Secretariat of education delegates goals to schools and teachers and brings other system elements in line with the delegated goals	C. Parents expressed initial resistance to the reform, but regular dialogue from the mayor and secretariat increased support. Parents were encouraged to reinforce learning goals and ensure that their children attend school more
Finance		H. Federal education funding increased for poor municipalities, including Sobral	G. Financial autonomy devolved to school level, giving more financial independence and responsibility for results	
Support			D. Teachers provided with sequenced learning objectives, structured teaching and learning materials, training and professional development and ongoing feedback and support through classroom observations, all aligned with learning goals	
Information	I. Information on low learning from new assessments were shared publicly by the mayor to increase citizen buy-in for improving learning		E. Use of information on learning a top priority for education leadership, with one-third of the time and effort dedicated to this - Twice-yearly assessments used by education leadership to measure progress and inform course correction and strategy - Teachers supported the use of continuous assessment in the classroom for regular feedback on student progress and to inform adjustments to instruction	
Motivation			F. Financial incentives for teachers, in-school pedagogical coordinators and principals for achieving learning goals - Public recognition events for high-performing teachers	

Source: Kaffenberger and Spivack (2023).

Within the management relationship, other elements were brought into alignment with learning goals: greater support for teachers (D, Figure 10), new information collected through regular assessments and progress measured through assessment results (E, Figure 10), and new incentives provided to motivate teachers and school leaders (F, Figure 10). All these reform elements were coherent with each other and coherent with the learning goals established by leadership. The reform package resembles a structured pedagogy programme, which the Global Education Evidence Advisory Panel (GEEAP) regards as a highly effective evidence-based approach to improve learning (a "great buy" (Global Education Evidence Advisory Panel 2023)).

This mapping provides compelling evidence that Sobral's reform created coherence for learning within the compact and management relationships and across all five design elements, corresponding to the substantial learning improvements achieved from 2005-2017. An early write up of the Sobral reform aligns with these findings, stating that Sobral achieved its success because of "its ability to converge the whole education system toward learning" (Loureiro and Cruz 2020).

Turning to Indonesia, we studied the reform known as the '2005 Teacher Law', which aimed to improve learning outcomes (de Ree et al. 2018; Chang et al. 2014). Initially drafted as a multifaceted reform effort, subsequent political processes watered it down, resulting in an enacted reform that was much narrower in scope. The results of our mapping of the reform are shown in Figure 11.

The original reform intended to improve education outcomes through merit-based teacher certification (B and C, Figure 11), a rigorous external evaluation and certification of teacher quality (G, Figure 11), comprehensive support and training for teachers who did not pass the certification (F, Figure 11), and large salary increases for teachers who passed the certification (D and H, Figure 11). Our mapping suggests that the original version of the reform addressed multiple system levers in a coherent way and would likely increase system coherence for learning.

However, political compromises led to the removal of key components (A, Figure 11). In particular, the external evaluations, support for struggling teachers, and motivational components were removed – described as 'enacted reform' in cells C, E, G, and H in Figure 11. Instead, the enacted reform provided a nearly universal doubling of teacher salaries, without the other associated components (B and F in Figure 11). We find no evidence that the enacted reform took a systems approach nor increased system coherence for learning; instead the reform suffered from incoherence within the delegation row and the management column. An independent impact evaluation found that the reform had no effect on student learning (de Ree et al. 2018).

Figure 11 Mapping of elements of the 2005 teacher reform in Indonesia to the education systems framework.

Five design elements	Principal–agent relationships of accountability			
	Politics	**Compact**	**Management**	**Voice & Choice**
Delegation	A. Teachers groups argue that higher salaries and professional status will improve performance - Pressure from teachers' groups to dilute aspects of the law, in particular, the teacher certification process	B. Intended reform: delegation from legislative authorities to adopt pay raises for certified teachers to improve learning. Enacted reform: legal provisions on teacher certification significantly diluted, producing a de facto universal salary increase	C. Intended reform: Delegation of quality improvement for teaching through merit-based certification process. Enacted reform: merit-based components replaced with superficial effectively universal certification process	
Finance		D. Additional financial resources needed for salary increases financed by a constitutional amendment passed around the same time as mandating 20% of government spending go to education	E. Intended reform: Finance provided to raise salaries for teachers who pass external evaluation for merit-based certification. Enacted reform: Finance provided to raise salaries for teachers who submit a portfolio and/or complete a two-week course	
Support			F. Intended reform: Comprehensive support and training to teachers who do not pass the certification process. Enacted reform: Completion of a two-week course allows nearly automatic certification	
Information			G. Intended reform: Rigorous external evaluation to verify quality of teacher pedagogical knowledge. Enacted reform: Teacher quality superficially verified through portfolio review or a two-week course.	
Motivation			H. Intended reform: Salary increase for teachers who pass rigorous certification process and bonuses for those serving marginalized locations; Enacted reform: A de facto nearly universal salary increase not contingent on performance.	

Source: Kaffenberger and Spivack (2023).

The political economy dynamics varied significantly between the two contexts. In Sobral, for instance, the mayor wielded considerable political influence to enact an initially controversial reform, and actively worked to gain support from officials, community members, and parents. In Indonesia, the political economy dynamics were quite different; teachers' groups were able to modify the initial reform, leading to a version that was less effective in improving learning outcomes.

Together, our investigations of Sobral's and Indonesia's reforms indicate that system coherence for learning is indeed associated with improved outcomes. We consider this analysis to lay the groundwork for future in-depth investigations into the causal relationships between system coherence and learning outcomes. In future work, the framework can also be applied prospectively to diagnose incoherence and guide future reforms, in particular by identifying potential shortcomings or risks that could impact upcoming initiatives. Notably, at least eight non-governmental organisations have used this framework in collaboration with government partners to conduct prospective diagnostics and identify system incoherence in Pakistan, Ecuador, South Africa, India, Uganda, and Ghana (Spivack, Silberstein, and Hwa 2023).

5.3. Three approaches for analysing system coherence for learning

In the final paper submitted for this PhD by Publication my coauthors and I review three distinct approaches to analyse system coherence for learning: learning trajectories, ALIGNS principles, and the education systems framework discussed in Section 5.2 (Kaffenberger, Silberstein, and Spivack 2023) (paper 9, Table 1). Evaluation at the system level remains a challenge and different approaches may provide complementary insights. This paper aims to illustrate the value of system analysis in general, and the use of complementary analysis more specifically, to diagnose challenges with learning, and identify ways forward for policy making. We discuss each approach in turn.

Learning trajectories focus on alignment or misalignment between children's learning progress and curricular or instructional expectations, as discussed in some depth in Section 2.1. By analysing grade-specific and standardised learning data, they give information on the extent to which children's learning is keeping pace with grade-level curricular expectations.

Using UNICEF's MICS data, we analyse learning trajectories for 22 low- and lower-middle income countries and regions for which this data was available at the time of our study, applying the learning trajectories methods in Kaffenberger and Pritchett (2020) to this new data source. MICS foundational learning assessments cover children aged 7-14 in each surveyed household and measure typical grade 2 level skills (UNICEF 2022),[33] allowing us to examine the alignment between children's grade level, children's learning progressions, and typical grade-level curricular expectations.

[33] We refer to these as grade 2-3 level skills as expectations vary somewhat across countries.

Our findings reveal significant levels of misalignment between children's grade levels, learning progressions, and typical grade-level curricular expectations. Across the 22 countries, only 23% of children in grade 3 have achieved grade 2 level foundational reading skills. By grade 6, on average only half of children have achieved grade 2 level reading skills. Analysing disaggregated learning trajectories indicates minimal differences by gender, geography (rural vs. urban), and income level, with girls outperforming boys by four percentage points in grade 3. Even among children in the highest wealth quintile, only 39% demonstrate foundational reading skills in grade 3. These findings highlight large divergences between expectations and children's actual learning progressions. Because instruction typically follows grade-level curricular expectations, many children who have not achieved foundational skills are unlikely to be able to engage in learning in later grades.

The second approach focuses on system coherence at the instructional level. Using a set of four principles, which we refer to as the ALIGNS principles, allows us to analyse alignment of learning goals, curriculum, assessments, teacher support, and instruction, and points to ways to improve alignment in different contexts (Hwa, Kaffenberger, and Silberstein 2020).[34]

The first principle includes setting clear learning goals in line with children's current learning levels. Such goals feature, for instance, in the successful Sobral reform, discussed in section 4.2, as well as successful programmes in Kenya (Piper et al. 2018; Freudenberger and Davis 2017), Mexico (Crouch 2020), as well as other settings (Gove and Wetterberg 2011). These goals are often informed by assessments shedding new light on low learning. The second principle is to align instruction with children's current learning level and targeted progress. While it may seem obvious to align instruction with children's learning levels, this is typically not the case (Muralidharan and Singh 2021; Pritchett and Beatty 2015; Rodriguez-Segura and Mbiti 2022).

The third principle is to provide effective support to teachers which helps them align instruction with the goals and children's learning levels. Evidence suggests that ongoing support, for instance in the form of coaching, is an important component to success (Ardington 2021). The final principle represents the need to tailor any efforts to improve system alignment to the opportunities and constraints of the context. In some contexts, an overhaul of the national curriculum to better align it with children's learning levels and needs may be possible, while in others aligning instructional approaches within the strictures of the existing curriculum may be most feasible.

Finally, using an education systems diagnostic approach can yield complementary insights to the two approaches already discussed in this section. As an illustration, we focus on successful efforts of a

[34] In previous work we reviewed three literatures: the cognitive science literature on how children learn, the educational research at the classroom level, and evaluations of programmes aiming to improve instructional alignment. This led us to a desk review of 12 approaches that have been used across more than 30 countries to assess alignment between curriculum, assessment, teacher support and instruction (Hwa, Kaffenberger, and Silberstein 2020).

non-governmental organization in South Africa to enhance learning by improving system coherence for learning. To conduct the diagnostic exercise we use the same framework and approach as in Kaffenberger and Spivack (2023), discussed in section 4.2, and apply it to a new programme, namely the work of Funda Wande, an education NGO in South Africa that aims to improve foundational learning in government schools. Formal impact evaluations have shown that Funda Wande's programmes improved learning outcomes (Ardington 2021; 2023), and we investigate the role that improved system coherence for learning may have played in achieving those outcomes. Funda Wande provides a unique example in which an NGO addresses multiple system constraints in government schools, illustrating how the systems framework can be applied to non-governmental efforts.

Our study indicates that Funda Wande brought multiple education system relationships and elements into alignment with each other, increasing coherence for learning. Within the Management column of the systems framework, our analysis reveals that Funda Wande developed new teaching and learning materials that met students' learning needs and aligned with government mandates to teach in local languages (C, Figure 12). These materials also provided significant support to teachers, in the form of teacher guides and lesson plans, and teachers were offered quality training, ongoing coaching, and resources such as video demonstrations of teaching techniques (E, Figure 12) (Funda Wande 2019). Furthermore, teachers received incentives in the form of a certification programme following additional professional training (F, Figure 12) (Taylor 2021). Funda Wande also innovated financially, producing materials at low-cost (D, Figure 12).

Figure 12 System alignment in Funda Wande's approach to improving foundational learning in government schools in South Africa.

Five design elements	Principal–agent relationships of accountability			
	Politics	Compact	Management	Voice & Choice
Delegation		**A** Build government support for the foundational learning agenda with clear goals (100% of children reading for meaning and calculating with confidence by 2030)	**C** A. Align materials and training with government mandate to teach in local languages B. Ensure that materials are aligned with mandated curriculum and officially sanctioned by authorities	
Finance		**B** Focus attention on leveraging philanthropic money to improve public sector performance	**D** Develop reading materials for children in local language, print them in anthologies to reduce costs and make them affordable for low-performing schools	
Support			**E** Develop teacher training and coach training programs aimed at preparing teachers to teach reading and basic math in local languages	
Information				
Motivation			**F** Offer teacher trainings in foundational skills instruction as part of a degree certificate at a university	

Source: Kaffenberger, Silberstein, and Spivack (2023)

Within the Compact column of the systems framework, Funda Wande undertook significant policy engagement efforts to build and maintain broad government commitment to improving learning (A, Figure 12) (Samji and Kapoor 2022). They also rallied philanthropic funding towards these goals (B, Figure 12). Our analysis suggests that by addressing multiple, interdependent system components, Funda Wande's work contributed to improving system coherence for learning.

Our study underlines both the value of system wide analysis, and the contribution of complementary approaches. The approaches used contribute to our understanding of system coherence at the curricular, instructional, and reform levels, demonstrating a toolbox for analysing education system coherence for learning.

6. Conclusion

While most children in LMICs now attend at least some schooling, most learn little while there. In Sub-Saharan Africa, 90% of 10-year-olds are in 'learning poverty' meaning they cannot read and understand a simple story (World Bank 2022). This has life-long consequences. In many countries, over half of young adults who completed primary schooling remain functionally illiterate (Kaffenberger and Pritchett 2020).

The papers being submitted for this PhD by Publication make four contributions. They have introduced a novel analytical method for analysing learning outcomes, investigated the consequences of low learning for children's later life outcomes, proposed new ways to model policy approaches for improving learning, and examined the hypothesis that system incoherence for learning constrains learning outcomes. The findings in these papers have several key implications.

First, it is evident that children often fall behind in learning during their early years of primary school and struggle to catch up later. Once learning trajectories plateau, they rarely steepen again. This underscores the importance of interventions targeting foundational skills in the early primary school years. Equipping children with essential foundational skills enables them to better grasp the curriculum and instruction and stay engaged in learning longer.

Second, because learning may play a larger role in schooling and later life outcomes than previously understood, improving learning should be among the policy options considered for achieving many development aims. For instance, while extensive health research investigates ways to reduce child mortality through health-related interventions, findings discussed in this critical analysis suggest that policies to improve learning achievements – not often considered among health interventions – should also be considered as a means for achieving such ends.

Finally, these papers support the hypothesis of system coherence as a driver of learning. Aligning different parts of an education system towards achieving a common aim, as was done in Sobral, Brazil between 2005 and 2017, can yield substantial effects. Incoherence is often present but hidden, making methods such as the SEC and education systems diagnostics important tools for uncovering incoherence that may impede learning.

Future work can extend and expand on these findings. Further investigation of the causal links between different types of system coherence and learning outcomes would help test the causal role of system coherence in driving learning and help prioritise parts of an education system where coherence is most critical. While the SEC approach contributes to our ability to quantify alignment at the instructional level, similar methods for quantifying alignment at the reform level are absent and could be developed. Questions remain about the degree of system alignment needed for improving learning outcomes, and refining measurement of system alignment would facilitate such analysis.

Furthermore, future work can also advance the modelling of educational policies and programmes, in line with the structural model developed and used in these papers. Modeling has a much deeper history in health than in education, and education researchers can learn from health's examples. Future work can refine the parameters, data needs and data sources, and pursue country-specific and group-disaggregated modelling of education outcomes.

On the policy side, using learning trajectories to inform which ages and grades should be targeted for intervention in particular contexts holds promise. While the papers being submitted for this PhD by Publication analysed learning trajectories at the national level, learning trajectories could also be used by teachers at the classroom level to understand and track the learning progress of the children in their classroom.

Efforts to incorporate learning into measures of educational poverty can also be advanced. Additional data can be used to analyse education poverty standards, compare education poverty across and within countries, and track progress over time. These measures can also enable advocacy and commitment to addressing educational poverty, as was achieved with measures of income poverty (Jolliffe and Prydz 2016).

The papers being submitted towards this PhD by Publication contribute to the growing field of systems thinking within international education research. They point towards policy and future research that can help improve learning achievement. My aspiration is that they represent the beginning of an ongoing research and policy agenda to improve children's learning, lives, and life chances.

Appendix 1. Papers contributing to PhD by Publication

A.1. Kaffenberger, Michelle, and Lant Pritchett. 2020. “Aiming Higher: Learning Profiles and Gender Equality in 10 Low- and Middle-Income Countries.” *International Journal of Educational Development* 79 (November): 102272. https://doi.org/10.1016/j.ijedudev.2020.102272.

A.2. Kaffenberger, Michelle, Lant Pritchett, and Martina Viarengo. 2023. “Towards a Right to Learn: Concepts and Measurement of Global Education Poverty.” In *Research Handbook on Measuring Poverty and Deprivation*, edited by Jacques Silber. Edward Elgar Publishing. https://doi.org/10.4337/9781800883451.00032.

A.3. Kaffenberger, Michelle, and Lant Pritchett. 2021b. “Effective Investment in Women’s Futures: Schooling with Learning.” *International Journal of Educational Development* 86 (October): 102464. https://doi.org/10.1016/j.ijedudev.2021.102464.

A.4. Kaffenberger, Michelle, Danielle Sobol, and Debi Spindelman. 2023. “The Role of Learning in School Persistence and Dropout: A Longitudinal Mixed Methods Study in Four Countries.” *International Journal of Educational Research* 121 (January): 102232. https://doi.org/10.1016/j.ijer.2023.102232.

A.5. Kaffenberger, Michelle, and Lant Pritchett. 2021a. “A Structured Model of the Dynamics of Student Learning in Developing Countries, with Applications to Policy.” *International Journal of Educational Development* 82 (April): 102371. https://doi.org/10.1016/j.ijedudev.2021.102371.

A.6. Kaffenberger, Michelle. 2021. “Modelling the Long-Run Learning Impact of the Covid-19 Learning Shock: Actions to (More than) Mitigate Loss.” *International Journal of Educational Development* 81 (March): 102326. https://doi.org/10.1016/j.ijedudev.2020.102326.

A.7. Atuhurra, Julius, and Michelle Kaffenberger. 2022. “Measuring Education System Coherence: Alignment of Curriculum Standards, Examinations, and Teacher Instruction in Tanzania and Uganda.” *International Journal of Educational Development* 92 (July): 102598. https://doi.org/10.1016/j.ijedudev.2022.102598.

A.8. Kaffenberger, Michelle, and Marla Spivack. 2023. “System Coherence for Learning: Applications of the RISE Education Systems Framework.” In *Systems Thinking in International Education and Development Unlocking Learning for All?*, edited by Moira Faul and Laura Savage, 138–56. Edward Elgar Publishing. https://www.elgaronline.com/edcollchap-oa/book/9781802205930/book-part-9781802205930-18.xml.

A.9. Kaffenberger, Michelle, Jason Silberstein, and Marla Spivack. 2023. “Evaluating Systems: Three Approaches for Analyzing Education Systems and Informing Action.” In *Oxford Handbook of Program Design and Implementation Evaluation*, edited by Anu Rangarajan. Oxford, New York: Oxford University Press.

List of abbreviations

Abbreviation	Definition
DHS	Demographic and Health Surveys
ASER	Annual Status of Education Report
FCDO	Foreign, Commonwealth, and Development Office
FII surveys	Financial Inclusion Insights surveys
IRT	Item Response Theory
LAYS	Learning-Adjusted Years of Schooling
LMICs	Low- and Middle-Income Countries
MICS	Multiple Indicator Cluster Surveys
PISA	Programme for International Student Assessment
PISA-D	PISA for Development
PPF	Pedagogical Production Function
RISE Programme	Research on Improving Systems of Education Programme
SACMEQ	Southern and Eastern Africa Consortium for Monitoring Education Quality
SDG	Sustainable Development Goal
SEC	Surveys of Enacted Curriculum

Bibliography

Abuya, Benta, Moses Oketch, and Peter Musyoka. 2013. "Why Do Pupils Dropout When Education Is 'Free'? Explaining School Dropout among the Urban Poor in Nairobi." *Compare: A Journal of Comparative and International Education* 43 (6): 740–62. https://doi.org/10.1080/03057925.2012.707458.

Adeniran, Adedeji, Sixtus C. Onyekwere, Anthony Okon, Julius Atuhurra, Rastee Chaudhry, and Michelle Kaffenberger. 2023. "Instructional Alignment in Nigeria Using the Surveys of Enacted Curriculum." RISE Working Paper. Research on Improving Systems of Education (RISE).

Aiyar, Yamini, Vincy Davis, Gokulnath Govindan, and Taanya Kapoor. 2021. "Rewriting the Grammar of the Education System: Delhi's Education Reform (A Tale of Creative Resistance and Creative Disruption)." Research on Improving Systems of Education (RISE). https://doi.org/10.35489/BSG-RISE-Misc_2021/01.

Anderson, Lorin W., and David R. Krathwohl, eds. 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Longman.

Angrist, Noam, Micheal Ainomugisha, Sai Pramod Bathena, Peter Bergman, Colin Crossley, Claire Cullen, Thato Letsomo, et al. 2023. "Building Resilient Education Systems: Evidence from Large-Scale Randomized Trials in Five Countries." Working Paper. Working Paper Series. National Bureau of Economic Research. https://doi.org/10.3386/w31208.

Ardington, Cally. 2021. "Impact Evaluation of Funda Wande Coaching Intervention Midline Findings." Cape Town: Southern Africa Labour and Development Research Unit. https://fundawande.org/img/cms/news/IMPACT%20EVALUATION%20OF%20FUNDA%20WANDE%20COACHING%20INTERVENTION%20MIDLINE2_v3.pdf.

———. 2023. "Funda Wande Eastern Cape Workbooks Evaluation: Endline Report." University of Cape Town. https://fundawande.org/img/cms/news/EC%20Cohort%20C%20Wave%203%20Report%20Mar%202022%20V04.pdf.

Ardington, Cally, Gabrielle Wills, and Janeli Kotze. 2021. "COVID-19 Learning Losses: Early Grade Reading in South Africa." *International Journal of Educational Development* 86 (October):102480. https://doi.org/10.1016/j.ijedudev.2021.102480.

ASER Centre. 2023. "Annual Status of Education Report (Rural) 2022." http://img.asercentre.org/docs/ASER%202022%20report%20pdfs/All%20India%20documents/aserreport2022.pdf.

Atuhurra, Julius, Rastee Chaudhry, Tahrima Hossain, and Michelle Kaffenberger. 2023. "Instructional Alignment in Nepal Using the Surveys of Enacted Curriculum." RISE Insight. Research on Improving Systems of Education (RISE). https://doi.org/10.35489/BSG-RISE-RI_2023/057.

Atuhurra, Julius, and Michelle Kaffenberger. 2022. "Measuring Education System Coherence: Alignment of Curriculum Standards, Examinations, and Teacher Instruction in Tanzania and Uganda." *International Journal of Educational Development* 92 (July):102598. https://doi.org/10.1016/j.ijedudev.2022.102598.

Banerjee, Abhijit, Rukmini Banerji, James Berry, Esther Duflo, Harini Kannan, Shobhini Mukerji, Marc Shotland, and Michael Walton. 2017. "From Proof of Concept to Scalable Policies: Challenges and Solutions, with an Application." *Journal of Economic Perspectives* 31 (4): 73–102. https://doi.org/10.1257/jep.31.4.73.

Banerji, Rukmini, Suman Bhattacharjea, and Wilima Wadhwa. 2013. "The Annual Status of Education Report (ASER)." *Research in Comparative and International Education* 8 (3): 387–96. https://doi.org/10.2304/rcie.2013.8.3.387.

Banik, Arindam, and Debasis Neogi. 2015. "Poverty and Earning Compulsions for the Family Have Pushed Children out of Schools: A Study in Dropouts in Basic Education Level in North-East India." *International Journal of Social Economics* 42 (10): 946–58. https://doi.org/10.1108/IJSE-02-2014-0023.

Barro, Robert J., and Jong Wha Lee. 2013. "A New Data Set of Educational Attainment in the World, 1950–2010." *Journal of Development Economics* 104 (September):184–98. https://doi.org/10.1016/j.jdeveco.2012.10.001.

Barros, Andreas de, and Alejandro J. Ganimian. 2023. “The Foundational Math Skills of Indian Children.” *Economics of Education Review* 92 (February):102336. https://doi.org/10.1016/j.econedurev.2022.102336.

Bau, Natalie, Jishnu Das, and Andres Yi Chang. 2021. “New Evidence on Learning Trajectories in a Low-Income Setting.” *International Journal of Educational Development* 84 (July):102430. https://doi.org/10.1016/j.ijedudev.2021.102430.

Beatty, Amanda, Emilie Berkhout, Luhur Bima, Menno Pradhan, and Daniel Suryadarma. 2021. “Schooling Progress, Learning Reversal: Indonesia’s Learning Profiles between 2000 and 2014.” *International Journal of Educational Development* 85 (September):102436. https://doi.org/10.1016/j.ijedudev.2021.102436.

Bedi, Arjun S., and Jeffery H. Marshall. 2002. “Primary School Attendance in Honduras.” *Journal of Development Economics* 69 (1): 129–53. https://doi.org/10.1016/S0304-3878(02)00056-1.

Biddlecom, Ann, Richard Gregory, Cynthia B. Lloyd, and Barbara S. Mensch. 2008. “Associations Between Premarital Sex and Leaving School in Four Sub-Saharan African Countries.” *Studies in Family Planning* 39 (4): 337–50. https://doi.org/10.1111/j.1728-4465.2008.00179.x.

Blank, Rolf, Andrew C. Porter, and John Smithson. 2001. “New Tools for Analyzing Teaching, Curriculum and Standards in Mathematics and Science. Results from Survey of Enacted Curriculum Project. Final Report.” Washington, D.C.: Council of chief state school officers. https://files.eric.ed.gov/fulltext/ED458275.pdf.

Bowles, Samuel. 1970. “Towards an Educational Production Function.” In *Education, Income, and Human Capital*, edited by W. Lee Hansen, 11–70. NBER. https://www.nber.org/books-and-chapters/education-income-and-human-capital/towards-educational-production-function.

Boyden, Jo. 2013. “‘We’Re Not Going to Suffer like This in the Mud’: Educational Aspirations, Social Mobility and Independent Child Migration among Populations Living in Poverty.” *Compare: A Journal of Comparative and International Education* 43 (5): 580–600. https://doi.org/10.1080/03057925.2013.821317.

Burdett, Newman. 2017. “Review of High Stakes Examination Instruments in Primary and Secondary School in Developing Countries.” Research on Improving Systems of Education (RISE). https://doi.org/10.35489/BSG-RISE-WP_2017/018.

Chang, Mae Chu, Sheldon Shaeffer, Samer Al-Samarrai, Andrew B Ragatz, Joppe de Ree, and Ritchie Stevenson. 2014. “Teacher Reform in Indonesia.” *World Bank*, 259.

City, Elizabeth A, Richard F Elmore, Sarah E Fiarman, and Lee Teitel. 2009. “Instructional Rounds in Education.”

Cleland, J. G., and J. K. Van Ginneken. 1988. “Maternal Education and Child Survival in Developing Countries: The Search for Pathways of Influence.” *Social Science & Medicine (1982)* 27 (12): 1357–68. https://doi.org/10.1016/0277-9536(88)90201-8.

Crivello, Gina, and Nikki van der Gaag. 2016. “Between Hope and a Hard Place: Boys and Young Men Negotiating Gender, Poverty and Social Worth in Ethiopia.” *Young Lives Working Paper*, no. 160. https://ora.ox.ac.uk/objects/uuid:e5c3b3d3-4efb-4ef7-832b-ad8adc4f0daa/.

Crouch, Luis. 2020. “Systems Implications for Core Instructional Support Lessons from Sobral (Brazil), Puebla (Mexico), and Kenya.” Insight Note. Research on Improving Systems of Education (RISE). https://doi.org/10.35489/BSG-RISE-RI_2020/020.

Crouch, Luis, and Joseph DeStefano. 2017. “Doing Reform Differently: Combining Rigor and Practicality in Implementation and Evaluation of System Reforms.” International Development Working Paper 2017–01. RTI International. https://www.rti.org/publication/doing-reform-differently/fulltext.pdf.

Dodd, Peter J., Courtney M. Yuen, Charalambos Sismanidis, James A. Seddon, and Helen E. Jenkins. 2017. “The Global Burden of Tuberculosis Mortality in Children: A Mathematical Modelling Study.” *The Lancet Global Health* 5 (9): e898–906. https://doi.org/10.1016/S2214-109X(17)30289-9.

Duc, Le Thuc, and Tran Ngo Minh Tam. 2013. “Why Children in Vietnam Drop out of School and What They Do After That.” *Young Lives Working Paper*, no. 102.

Duflo, Esther. 2001. “Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment.” *American Economic Review* 91 (4): 795–813. https://doi.org/10.1257/aer.91.4.795.

Elmore, Richard. 2010. “Getting to Scale with Good Educational Practice.” *Harvard Educational Review* 66 (1): 1–27. https://doi.org/10.17763/haer.66.1.g73266758j348t33.
Faul, Moira, and Laura Savage, eds. 2023. *Systems Thinking in International Education and Development: Unlocking Learning for All?* Edward Elgar Publishing. https://www.elgaronline.com/edcollbook-oa/book/9781802205930/9781802205930.xml.
Fehrler, Sebastian, Katharina Michaelowa, and Annika Wechtler. 2009. “The Effectiveness of Inputs in Primary Education: Insights from Recent Student Surveys for Sub-Saharan Africa.” *The Journal of Development Studies* 45 (9): 1545–78. https://doi.org/10.1080/00220380802663625.
Filmer, Deon, Halsey Rogers, Noam Angrist, and Shwetlena Sabarwal. 2020. “Learning-Adjusted Years of Schooling (LAYS): Defining a New Macro Measure of Education.” *Economics of Education Review* 77 (August):101971. https://doi.org/10.1016/j.econedurev.2020.101971.
Freudenberger, Elizabeth, and Jeff Davis. 2017. “Tusome External Evaluation: Midline Report.”
Funda Wande. 2019. “Funda Wande Annual Report 2019.” Cape Town. https://fundawande.org/img/cms/news/FW%202019%20Annual%20Report_1.pdf.
Gakidou, Emmanuela, Krycia Cowling, Rafael Lozano, and Christopher JL Murray. 2010. “Increased Educational Attainment and Its Effect on Child Mortality in 175 Countries between 1970 and 2009: A Systematic Analysis.” *The Lancet* 376 (9745): 959–74. https://doi.org/10.1016/S0140-6736(10)61257-3.
Ganimian, Alejandro J., and Richard J. Murnane. 2016. “Improving Education in Developing Countries: Lessons From Rigorous Impact Evaluations.” *Review of Educational Research* 86 (3): 719–55.
Glewwe, Paul, Michael Kremer, and Sylvie Moulin. 2009. “Many Children Left Behind? Textbooks and Test Scores in Kenya.” *American Economic Journal: Applied Economics* 1 (1): 112–35. https://doi.org/10.1257/app.1.1.112.
Glewwe, Paul, Sylvie Lambert, and Qihui Chen. 2020. “Chapter 15 - Education Production Functions: Updated Evidence from Developing Countries.” In *The Economics of Education (Second Edition)*, edited by Steve Bradley and Colin Green, 183–215. Academic Press. https://doi.org/10.1016/B978-0-12-815391-8.00015-X.
Glewwe, Paul, and Karthik Muralidharan. 2016. “Chapter 10 - Improving Education Outcomes in Developing Countries: Evidence, Knowledge Gaps, and Policy Implications.” In *Handbook of the Economics of Education*, edited by Eric A. Hanushek, Stephen Machin, and Ludger Woessmann, 5:653–743. Elsevier. https://doi.org/10.1016/B978-0-444-63459-7.00010-5.
Global Education Evidence Advisory Panel. 2023. “2023 Cost-Effective Approaches to Improve Global Learning.” World Bank. https://documents1.worldbank.org/curated/en/099420106132331608/pdf/IDU0977f73d7022b1047770980c0c5a14598eef8.pdf.
Global Education Monitoring Report Team. 2021. “Global Education Monitoring Report, 2021/2: Non-State Actors in Education: Who Chooses? Who Loses?” https://unesdoc.unesco.org/ark:/48223/pf0000379875.
Global Partnership for Education. 2022. “GPE 2025 Strategic Plan.” Global Partnership for Education. https://www.globalpartnership.org/content/gpe-2025-strategic-plan.
Gove, Amber, and Anna Wetterberg, eds. 2011. *The Early Grade Reading Assessment: Applications and Interventions to Improve Basic Literacy*. *RTI International*. Research Triangle Park, NC: RTI International. https://eric.ed.gov/?id=ED531301.
Government of Tanzania. 1975. *The Institute of Education Act, 1975*.
———. 2019. *The National Examinations Council of Tanzania Act, 2019*.
Government of Uganda. 1973. *The National Curriculum Development Centre Act 1973*.
———. 1983. *Uganda National Examinations Board Act 1983*.
Hanushek, Eric A. 2020. “Chapter 13 - Education Production Functions.” In *The Economics of Education (Second Edition)*, edited by Steve Bradley and Colin Green, 161–70. Academic Press. https://doi.org/10.1016/B978-0-12-815391-8.00013-6.
Hanushek, Eric A., and Ludger Woessmann. 2008. “The Role of Cognitive Skills in Economic Development.” *Journal of Economic Literature* 46 (3): 607–68. https://doi.org/10.1257/jel.46.3.607.

Hanushek, Eric A., Victor Lavy, and Kohtaro Hitomi. 2008. “Do Students Care about School Quality? Determinants of Dropout Behavior in Developing Countries.” *Journal of Human Capital* 2 (1): 69–105. https://doi.org/10.1086/529446.

Heesterbeek, Hans, Roy M. Anderson, Viggo Andreasen, Shweta Bansal, Daniela De Angelis, Chris Dye, Ken T. D. Eames, et al. 2015. “Modeling Infectious Disease Dynamics in the Complex Landscape of Global Health.” *Science* 347 (6227): aaa4339. https://doi.org/10.1126/science.aaa4339.

Howie, Sarah J. 2022. “Regional Studies in Non-Western Countries, and the Case of SACMEQ.” In *International Handbook of Comparative Large-Scale Studies in Education: Perspectives, Methods and Findings*, edited by Trude Nilsen, Agnes Stancel-Piątak, and Jan-Eric Gustafsson, 419–68. Springer International Handbooks of Education. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-88178-8_18.

Hwa, Yue-Yi, Michelle Kaffenberger, and Jason Silberstein. 2020. “Aligning Levels of Instruction with Goals and the Needs of Students (ALIGNS): Varied Approaches, Common Principles.” Research on Improving Systems of Education (RISE). https://doi.org/10.35489/BSG-RISE-RI_2020/022.

Jensen, Robert. 2010. “The (Perceived) Returns to Education and the Demand for Schooling.” *The Quarterly Journal of Economics* 125 (2): 515–48. https://doi.org/10.1162/qjec.2010.125.2.515.

Jolliffe, Dean, Daniel Gerszon Mahler, Christoph Lakner, Aziz Atamanov, and Samuel Kofi Tetteh-Baah. 2022. “Assessing the Impact of the 2017 PPPs on the International Poverty Line and Global Poverty.” Policy Research Working Paper 9941. Washington, D.C.: World Bank.

Jolliffe, Dean, and Espen Beer Prydz. 2016. “Estimating International Poverty Lines from Comparable National Thresholds.” *The Journal of Economic Inequality* 14 (2): 185–98. https://doi.org/10.1007/s10888-016-9327-5.

Kaffenberger, Michelle. 2021. “Modelling the Long-Run Learning Impact of the Covid-19 Learning Shock: Actions to (More than) Mitigate Loss.” *International Journal of Educational Development* 81 (March):102326. https://doi.org/10.1016/j.ijedudev.2020.102326.

Kaffenberger, Michelle, and Lant Pritchett. 2020. “Aiming Higher: Learning Profiles and Gender Equality in 10 Low- and Middle-Income Countries.” *International Journal of Educational Development* 79 (November):102272. https://doi.org/10.1016/j.ijedudev.2020.102272.

———. 2021a. “A Structured Model of the Dynamics of Student Learning in Developing Countries, with Applications to Policy.” *International Journal of Educational Development* 82 (April):102371. https://doi.org/10.1016/j.ijedudev.2021.102371.

———. 2021b. “Effective Investment in Women’s Futures: Schooling with Learning.” *International Journal of Educational Development* 86 (October):102464. https://doi.org/10.1016/j.ijedudev.2021.102464.

Kaffenberger, Michelle, Lant Pritchett, and Martina Viarengo. 2023. “Towards a Right to Learn: Concepts and Measurement of Global Education Poverty.” In *Research Handbook on Measuring Poverty and Deprivation*, edited by Jacques Silber. Edward Elgar Publishing. https://doi.org/10.4337/9781800883451.00032.

Kaffenberger, Michelle, Jason Silberstein, and Marla Spivack. 2023. “Evaluating Systems: Three Approaches for Analyzing Education Systems and Informing Action.” In *Oxford Handbook of Program Design and Implementation Evaluation*, edited by Anu Rangarajan. Oxford, New York: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190059668.013.35.

Kaffenberger, Michelle, Danielle Sobol, and Debi Spindelman. 2023. “The Role of Learning in School Persistence and Dropout: A Longitudinal Mixed Methods Study in Four Countries.” *International Journal of Educational Research* 121 (January):102232. https://doi.org/10.1016/j.ijer.2023.102232.

Kaffenberger, Michelle, and Marla Spivack. 2023. “System Coherence for Learning: Applications of the RISE Education Systems Framework.” In *Systems Thinking in International Education and Development Unlocking Learning for All?*, edited by Moira Faul and Laura Savage, 138–56. Edward Elgar Publishing. https://www.elgaronline.com/edcollchap-oa/book/9781802205930/book-part-9781802205930-18.xml.

Levy, Brian. 2022. “How Political Contexts Influence Education Systems: Patterns, Constraints, Entry Points.” Working Paper. Research on Improving Systems of Education (RISE).
Loureiro, Andre, and Louise Cruz. 2020. “Achieving World-Class Education in Adverse Socioeconomic Conditions : The Case of Sobral in Brazil.” World Bank. https://openknowledge.worldbank.org/handle/10986/34150.
MacDonald, Dara. 2011. “Reproducing Inequality? The Process of Secondary School Abandonment in Rural Highland Peru.” *Young Lives Student Paper*. https://www.younglives.org.uk/sites/www.younglives.org.uk/files/YL-SP-MacDonald-MPhilDissertation-2011.pdf.
Mbiti, Isaac, Karthik Muralidharan, Mauricio Romero, Youdi Schipper, Constantine Manda, and Rakesh Rajani. 2019. “Inputs, Incentives, and Complementarities in Education: Experimental Evidence from Tanzania.” *The Quarterly Journal of Economics* 134 (3): 1627–73. https://doi.org/10.1093/qje/qjz010.
McMillan, James H. 2008. *Assessment Essentials for Standards-Based Education*. Corwin Press.
Mensch, Barbara S., Erica K. Chuang, Andrea J. Melnikas, and Stephanie R. Psaki. 2019. “Evidence for Causal Links between Education and Maternal and Child Health: Systematic Review.” *Tropical Medicine & International Health* 24 (5): 504–22. https://doi.org/10.1111/tmi.13218.
MoEST. 2018. “Education Sector Development Plan (2016/17 - 2020/21).” Governement of Tanzania.
Momo, Michelle S. M., Sofie J. Cabus, Kristof De Witte, and Wim Groot. 2019. “A Systematic Review of the Literature on the Causes of Early School Leaving in Africa and Asia.” *Review of Education* 7 (3): 496–522. https://doi.org/10.1002/rev3.3134.
Moore, Mark Harrison. 1995. *Creating Public Value: Strategic Management in Government*. Cambridge, Mass.: Harvard University Press.
Mugo, John Kabutha, Sara Jerop Ruto, Mary Goretti Nakabugo, and Zaida Mgalla. 2015. “A Call to Learning Focus in East Africa: Uwezo’s Measurement of Learning in Kenya, Tanzania and Uganda.” *Africa Education Review* 12 (1): 48–66. https://doi.org/10.1080/18146627.2015.1036564.
Muralidharan, Karthik, and Abhijeet Singh. 2021. “India’s New National Education Policy: Evidence and Challenges.” *Science* 372 (6537): 36–38. https://doi.org/10.1126/science.abf6655.
Opalo, Ken. 2022. “What Is the Point of Schooling? The Politics of Education Policy in Tanzania Since 1961.” 614. CGD Working Paper. Washington, DC: Center for Global Development. https://www.cgdev.org/publication/what-point-schooling-politics-education-policy-tanzania-1961.
Paglayan, Agustina S. 2022. “Education or Indoctrination? The Violent Origins of Public School Systems in an Era of State-Building.” *American Political Science Review* 116 (4): 1242–57. https://doi.org/10.1017/S0003055422000247.
Patrinos, Harry, Emiliana Vegas, and Rohan Carter-Rau. 2023. “An Analysis of COVID-19 Student Learning Loss.” *Oxford Research Encyclopedia of Economics and Finance*, August. https://doi.org/10.1093/acrefore/9780190625979.013.893.
Peet, Evan D., Günther Fink, and Wafaie Fawzi. 2015. “Returns to Education in Developing Countries: Evidence from the Living Standards and Measurement Study Surveys.” *Economics of Education Review* 49 (December):69–90. https://doi.org/10.1016/j.econedurev.2015.08.002.
Pichon-Riviere, Andrés, Andrea Alcaraz, Alfredo Palacios, Belén Rodríguez, Luz Myriam Reynales-Shigematsu, Márcia Pinto, Marianela Castillo-Riquelme, et al. 2020. “The Health and Economic Burden of Smoking in 12 Latin American Countries and the Potential Effect of Increasing Tobacco Taxes: An Economic Modelling Study.” *The Lancet Global Health* 8 (10): e1282–94. https://doi.org/10.1016/S2214-109X(20)30311-9.
Piper, Benjamin, Joseph Destefano, Esther M. Kinyanjui, and Salome Ong’ele. 2018. “Scaling up Successfully: Lessons from Kenya’s Tusome National Literacy Program.” *Journal of Educational Change* 19 (3): 293–321. https://doi.org/10.1007/s10833-018-9325-4.
Polikoff, Morgan S. 2012. “Instructional Alignment under No Child Left Behind.” *American Journal of Education* 118 (3): 341–68. https://doi.org/10.1086/664773.

Popova, Anna, David K Evans, Mary E Breeding, and Violeta Arancibia. 2022. “Teacher Professional Development around the World: The Gap between Evidence and Practice.” *The World Bank Research Observer* 37 (1): 107–36. https://doi.org/10.1093/wbro/lkab006.

Porter, Andrew C. 2002. “Measuring the Content of Instruction: Uses in Research and Practice.” *Educational Researcher* 31 (7): 3–14. https://doi.org/10.3102/0013189X031007003.

Pritchett, Lant. 2013. *The Rebirth of Education: Schooling Ain’t Learning*. Washington, D.C: Center for Global Development.

———. 2015. “Creating Education Systems Coherent for Learning Outcomes: Making the Transition from Schooling to Learning.” Working Paper 15/005. Research on Improving Systems of Education (RISE).

Pritchett, Lant, and Amanda Beatty. 2015. “Slow down, You’re Going Too Fast: Matching Curricula to Student Skill Levels.” *International Journal of Educational Development* 40 (January):276–88. https://doi.org/10.1016/j.ijedudev.2014.11.013.

Pritchett, Lant, and Justin Sandefur. 2020. “Girls’ Schooling and Women’s Literacy: Schooling Targets Alone Won’t Reach Learning Goals.” *International Journal of Educational Development* 78 (October):102242. https://doi.org/10.1016/j.ijedudev.2020.102242.

Psacharopoulos, George, and Harry Anthony Patrinos. 2004. “Returns to Investment in Education: A Further Update.” *Education Economics* 12 (2): 111–34. https://doi.org/10.1080/0964529042000239140.

Psaki, Stephanie R., Erica K. Chuang, Andrea J. Melnikas, David B. Wilson, and Barbara S. Mensch. 2019. “Causal Effects of Education on Sexual and Reproductive Health in Low and Middle-Income Countries: A Systematic Review and Meta-Analysis.” *SSM - Population Health* 8 (August):100386. https://doi.org/10.1016/j.ssmph.2019.100386.

Ravallion, Martin, Gaurav Datt, and Dominique van de Walle. 1991. “Quantifying Absolute Poverty in the Developing World.” *Review of Income and Wealth* 37 (4): 345–61. https://doi.org/10.1111/j.1475-4991.1991.tb00378.x.

Ree, Joppe de, Karthik Muralidharan, Menno Pradhan, and Halsey Rogers. 2018. “Double for Nothing? Experimental Evidence on an Unconditional Teacher Salary Increase in Indonesia.” *The Quarterly Journal of Economics* 133 (2): 993–1039. https://doi.org/10.1093/qje/qjx040.

Reimers, Fernando M. 2020. “Thinking Multidimensionally About Ambitious Educational Change.” In *Audacious Education Purposes: How Governments Transform the Goals of Education Systems*, edited by Fernando M. Reimers, 1–46. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-41882-3_1.

Rodriguez-Segura, Daniel. 2022. “EdTech in Developing Countries: A Review of the Evidence.” *The World Bank Research Observer* 37 (2): 171–203. https://doi.org/10.1093/wbro/lkab011.

Rodriguez-Segura, Daniel, and Isaac Mbiti. 2022. “Back to the Basics: Curriculum Reform and Student Learning in Tanzania.” Working Paper 22/099. Research on Improving Systems of Education (RISE). https://doi.org/10.35489/BSG-RISE-WP_2022/099.

Rojas, Vanessa, Gabriela Guerrero, and Jimena Vargas. 2016. “Gendered Trajectories Through Education, Work and Parenthood in Peru.” *Young Lives Working Paper*, no. 157. https://www.younglives.org.uk/sites/default/files/migrated/YL-WP157-Gendered-Trajectories-in-Peru.pdf.

Samji, Salimah, and Mansi Kapoor. 2022. “Funda Wande through the Lens of PDIA: Showcasing a Flexible and Iterative Learning Approach to Improving Educational Outcomes.” RISE Insight. Research on Improving Systems of Education (RISE). https://riseprogramme.org/publications/funda-wande-through-lens-pdia-showcasing-flexible-and-iterative-learning-approach.

Sellar, Sam, and Bob Lingard. 2014. “The OECD and the Expansion of PISA: New Global Modes of Governance in Education.” *British Educational Research Journal* 40 (6): 917–36. https://doi.org/10.1002/berj.3120.

Singh, Abhijeet. 2020. “Learning More with Every Year: School Year Productivity and International Learning Divergence.” *Journal of the European Economic Association* 18 (4): 1770–1813. https://doi.org/10.1093/jeea/jvz033.

Singh, Abhijeet, Mauricio Romero, and Karthik Muralidharan. 2024. “COVID-19 Learning Loss and Recovery: Panel Data Evidence from India.” *Journal of Human Resources*, April. https://doi.org/10.3368/jhr.0723-13025R2.

Spaull, Nicholas, and Janeli Kotze. 2015. “Starting behind and Staying behind in South Africa: The Case of Insurmountable Learning Deficits in Mathematics.” *International Journal of Educational Development* 41 (March):13–24. https://doi.org/10.1016/j.ijedudev.2015.01.002.

Spivack, Marla, Jason Silberstein, and Yue-Yi Hwa. 2023. “The RISE Education Systems Diagnostic Toolkit.” Research on Improving Systems of Education (RISE). https://doi.org/10.35489/BSG-RISE-Misc_2023/09.

Stenberg, Karin, Odd Hanssen, Melanie Bertram, Callum Brindley, Andreia Meshreky, Shannon Barkley, and Tessa Tan-Torres Edejer. 2019. “Guide Posts for Investment in Primary Health Care and Projected Resource Needs in 67 Low-Income and Middle-Income Countries: A Modelling Study.” *The Lancet Global Health* 7 (11): e1500–1510. https://doi.org/10.1016/S2214-109X(19)30416-4.

Tafere, Yisak, Workneh Abebe, and Asham Assazenew. 2009. “Young Lives Qualitative Research: Round 1 Ethiopia.” *Young Lives Technical Note*, no. 19.

Tafere, Yisak, and Nardos Chuta. 2016. “Gendered Trajectories of Young People through School, Work and Marriage in Ethiopia.” *Young Lives Working Paper*, no. 155. https://ora.ox.ac.uk/objects/uuid:794dd2ff-08a2-4f8b-acaf-bd9c08297501/.

Taylor, Nick. 2021. “Rhodes Evaluation of the Advanced Certificate in Foundation Phase Literacy Teaching.” Rhodes University. https://fundawande.org/img/cms/news/Rhodes_Evaluation%20of%20the%20Advanced%20Certificate%20in%20Foundation%20Phase%20Literacy%20Teaching.pdf.

Thorn, William. 2020. “Improving the Collection of Information on Literacy Proficiency in Household Surveys.” OECD Education Working Papers 240. Vol. 240. OECD Education Working Papers. https://doi.org/10.1787/d02155e2-en.

UNESCO. 2020. “Global Education Monitoring Report 2020: Inclusion and Education: All Means All.” Paris: UNESCO. https://www.unesco.org/gem-report/en/inclusion.

———. 2022. “Learning Trajectories.” GEM Report SCOPE. 2022. https://www.education-progress.org/en/articles/trajectories.

———. 2024. “Averages – GEM Report VIEW.” 2024. https://education-estimates.org/completion/averages/.

UNESCO Institute of Statistics. 2022. “MILO Report - MILO: Monitoring Impacts on Learning Outcomes.” UNESCO Institute of Statistics. https://milo.uis.unesco.org/report/.

UNICEF. 2022. “Are Children Really Learning? Exploring Foundational Skills in the Midst of a Learning Crisis.” https://data.unicef.org/resources/are-children-really-learning-foundational-skills-report/.

United Nations. 1948. “Universal Declaration of Human Rights.”

———. 2022. “Transforming Education Summit.” United Nations. United Nations. 2022. https://www.un.org/en/transforming-education-summit.

———. 2023. “2023 Global Multidimensional Poverty Index (MPI).” *Human Development Reports*. United Nations. https://hdr.undp.org/content/2023-global-multidimensional-poverty-index-mpi.

United Nations General Assembly. 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development*.

Uwezo Uganda. 2019. “Are Our Children Learning? Uwezo Uganda Eighth Learning Assessment Report.” Kampala: Twaweza East Africa.

Vennam, Uma, Anuradha Komanduri, and Jennifer Roest. 2016. “Gendered Trajectories through School, Work and Marriage in India.” *Young Lives Working Paper*, no. 156. https://www.younglives.org.uk/sites/default/files/migrated/YL-WP156-Vennam%20et%20al.pdf.

Vygotsky, L. S. 1978. *Mind in Society: Development of Higher Psychological Processes*. Harvard University Press. https://doi.org/10.2307/j.ctvjf9vz4.

Ward, Michael, Alan Penny, and Tony Read. 2006. “Education Reform in Uganda 1997 – 2004: Reflections on Policy, Partnership, Strategy and Implementation.” London: Department for International Development (DfID).

World Bank. 2004. *World Development Report 2004: Making Services Work for Poor People*. The World Bank. https://doi.org/10.1596/0-8213-5468-X.

———. 2022. “The State of Global Learning Poverty: 2022 Update.” The World Bank. https://thedocs.worldbank.org/en/doc/e52f55322528903b27f1b7e61238e416-0200022022/original/Learning-poverty-report-2022-06-21-final-V7-0-conferenceEdition.pdf.

World Conference on Education for All. 1990. *World Declaration on Education for All and Framework for Action to Meet Basic Learning Needs; 1990*.

Young Lives. 2016. *Towards a Better Future? Hopes and Fears from Young Lives*. Young Lives, University of Oxford.

Zuilkowski, Stephanie Simmons, Matthew C. H. Jukes, and Margaret M. Dubeck. 2016. “‘I Failed, No Matter How Hard I Tried’: A Mixed-Methods Study of the Role of Achievement in Primary School Dropout in Rural Kenya.” *International Journal of Educational Development* 50 (September):100–107. https://doi.org/10.1016/j.ijedudev.2016.07.002.