Educational Gaps in Latin American childhood: Regional Inequality in Learning Deprivation with Local Modulations

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Abstract. This research is a secondary analysis of a multivariate dataset coming from a large-scale assessment, coordinated by UNESCO in 15 Latin American countries (LAC), which was carried out for estimating the level of learning achievements of students at the end of primary education. The objective is to estimate the lack of quality in education across the region, based on the sociological concepts of absolute and relative deprivation, through a new learning deprivation index, as well as to offer robust evidence on the deep inequalities in learning outcomes among groups of population. Main results show strong evidences on how big gaps in learning outcomes are associated with socioeconomic status of students, pointing out that the profound lack of equity in LAC has become structural inequality beyond borders. This study establishes three milestones in educational research using the best available data. First, provides a direct method for estimating learning deprivation. Second, intra- and inter-country inequality is estimated from comparable socioeconomic deciles at regional level. Third, it was found that the intensity of learning deprivation, as a function of the SES, has an interplay with the wealth of the country and it is not possible to apply same strategies in all countries for developing inclusive and equitable educational for all.

1. Introduction
The unequal exercise of the right to education is a source of social and economic inequality. In the scenario prior to the current COVID pandemic, it was estimated that, worldwide, the primary total net enrollment rate was 92% and the primary completion rate was only 84%, with Sub-Saharan Africa being the most depressed region, with rates of 81% and 63%, respectively [1]. Furthermore, in the same period, 258 million children and youth were out of school [2], of which 59 million were of primary age, 62 million in lower secondary age, and 138 million of upper secondary age. To deal with this critical situation, the United Nations (UN) launched in 2015 the Sustainable Development Goal 4 (SDG-4) as part of the 2030 Agenda, from which 193 countries committed to 'Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all', which in practical and conceptual terms translates into focusing efforts on two pillars: learning and equity [3-5].

In Latin America and the Caribbean (LAC), the challenges to comply with the SDG-4 are enormous, since the primary total net enrollment rate is 95% and the primary completion rate is only 91% [6]. Additionally, in LAC are 72 million children living in poverty, only 6 of each 10 children between 3 and 4 years old receive early education, and more than 14 million children and adolescents are outside the educational system, 3.6 million of them in the primary stage and 7.7% outside of secondary education, while in developed countries this percentage is 2.1% [7]. This situation has multiple consequences in inequality, for example, children belonging to the richest families are 2.5
times more likely to attend school than those of the poorest families [6]. With these antecedents, LAC countries face new threats of deepening inequality in post-COVID era due mainly to the differential effect of the pandemic in absolute and relative learning deprivation, as well as the magnitude of the gaps between students coming from rich and poor families before and after the pandemic.

2. Material and Methods

With the aim of strengthening their educational policies, most of the countries in LAC are members of UNESCO’s Latin American Laboratory for the Evaluation of Educational Quality (LLECE), 15 of them participated in the Third Regional Comparative and Explanatory Study —TERCE, for its acronym in Spanish—, a large-scale assessment (LSA) designed through a sample design that assesses students to collect valid and reliable data on educational outcomes, along with a large number of factors associated with learning (FAL) [8]. The main objective of this project is to generate evidence and detect those variables that drive or limit learning outcomes of students in Numeracy, Literacy and Science for developing evidence-based policies that might help to close the gaps between students of all socioeconomic strata and among the countries of the region [8].

This research carries out a secondary analysis of this multivariate data set developed by UNESCO from TERCE’s results, a database produced with high quality standards in all its stages of sample design, data collection, processing and statistical estimates [9]. Thus, data is useful and sufficiently robust to estimate and compare learning outcomes and educational deprivation in those 15 LAC participating countries, as well as its relationship with the student’s Socioeconomic Status (SES) and other relevant social determinants [10].

For estimating the raw scores, psychometric parameters were estimated by Item Response Theory (IRT) through a 1P-Logistic model, specifically a Rasch model [9], following equation (1):

$$ P(Y_{ij} | \theta_i, \beta_j) = \frac{e^{(\theta_i - \beta_j)}}{1 + e^{(\theta_i - \beta_j)}} $$

where $Y_{ij}$ corresponds to the response of student $i$ to item $j$; $\theta_i \in (-\infty, \infty)$ refers to the ability of the student $i$ and $\beta_j \in (-\infty, \infty)$ represents the difficulty of item $j$ [11]. As raw scores of $\theta_i$ are in logits, mean and standard deviation are centered in $\mu = 0$ and $\sigma = 1$, however, final scores are linear transformed scores with $\mu = 500$ and $\sigma = 100$ for establishing a learning index $\ell_i = T(\theta_i) \forall i$, where student with higher levels of learning are more likely to have higher scores [11]. As the dataset has a relational structure, it is easy to join learning outcomes of the students with a unique ID for the dimensions of the explicit and implicit strata, FAL and the SES. Thus, SES have been properly segmented by regional cut-off points for producing regional deciles $\{D_j\}$ $j = 1, \ldots, 10$.

3. Structural Inequality in Learning Deprivation

According to Royce [12], structural inequality is ‘a situation in which a group of people recognizes a state of inequality in relation to other groups’, a state that might be perpetuated and reinforced by a confluence of unequal relationships in roles, functions, decisions, rights and opportunities. This idea helps to explain the big barriers to schooling and the unequal offer of educational services to groups of population according to the postcode, one of the main sources of structural inequality in LAC [12].

For measuring the level of learning deprivation, is necessary to measure it in two ways: absolute and relative. The first concept proposes that ‘there is an irreducible nucleus of needs that are common to every human being’ [13]. For attending this point, LSA’s results are classified for all students in $m$ levels of achievement $L_m$, $m = 0, 1, 2, 3$, a standard procedure based on a Bookmark process [9] developed from psychometrical and qualitative analysis for establishing the $m$ cut off points $\psi m$ in the same scale of $\ell_i$, where $\psi_0 = \alpha = \min (\ell_i) \forall i$, so the following equality holds

$$ n(e_i, D_j) = \sum_{k=1}^{p} n_k(e_i, D_j) = \sum_{k=1}^{p} n(C_k, e_i, D_j) = \sum_{k=1}^{p} \sum_{r=1}^{m} n_k(e_i, D_j; L_r) $$

(2)
In equation (2), the number \( n(ε_i, D_j) \) refers to valid students assessed at the region in stratum \( ε_i \) coming from the decile \( j \), \( n_k(ε_i, D_j) = n(C_k, ε_i, D_j) \), a number that identifies a group bounded by \((C_k, ε_i, D_j)\) inside the country \( k \); \( p \) is the total number of participating countries and \( L_m \) refers to one of the \( m \) levels of achievement reached by each group. Students suffering learning deprivation are those that did not meet the minimum standards according with the regional curriculum, grouped by \( L_0 \). Thus, the rate of learning deprivation in the country \( k \) for the \( j \)-th decile is given by equation (3).

\[
H_k(ε_i, D_j) = n_k(ε_i, D_j; L_0) \sum_{r=1}^{m} n_k(ε_i, D_j; L_r)\]

Figure 1 shows the distribution of the student population among the four achievement levels, disaggregated by socioeconomic deciles estimated from the SES. As can be seen, in the region, 37% of the students do not develop the minimum learning in the scientific field, 39% are located at level \( L_1 \) — elementary learning—, 17% at \( L_2 \) —the expected of an appropriate and timely educational process— and 7.4% reach level \( L_3 \), which exceeds standards provided by the regional curriculum [9]. However, the same Figure 1 shows how the relative participation of the private learning group varies according to the SES, being 10% for the \( D_{10} \)—those from families with greater socioeconomic advantages—and 63% for \( D_{01} \)—the group with the worst situation—.

![Figure 1. Distribution of levels of achievement among SES deciles.](image1)

![Figure 2. Relative flows of the distribution of levels of achievement among SES deciles.](image2)

Figure 2 shows the synthesis of absolute deprivation for each decile of the SES, which highlights the profound inequality in the distribution of learning levels among socioeconomic groups, which explains why the \( H \) function decreases monotonously as the SES increases. For example, 63 of each 100 poor students do not learn the minimum \((H_{D_{01}}=0.631)\), while in rich families the rate \( H_{D_{10}}=0.099 \), this means that, of every 100 students who do not develop elementary learning, 32 correspond to the first two deciles \((D_1 + D_2)\), while only 8 belong to the two highest deciles \((D_9 + D_{10})\). On the contrary, of every 100 students in the outstanding group \( L_3 \), only 3 come from the deciles \( D_1 \) and \( D_2 \), while 55 come from the groups \( D_9 \) and \( D_{10} \), 20 and 35, respectively, indicating the big gap between students coming from poor and rich families.

Now, regarding the estimation of relative deprivation, the sociological proposal is that 'needs, thresholds and satisfactions are determined by each society', a sentence that might be interpreted in this context as ‘how deep is deprivation’, which can be estimated through the function \( λ^i(C_k, ε_i, D_j, T(θ^i)) \in [0,1] \), a real value measuring the intensity of learning deprivation in the \( i \)-th student, measured as the distance from the score reached by her or him to the first cut-off point \( ψ_1 \), considering the trajectory given by the function \( S_{L_0}(α, β) : \mathbb{R} \to [0,1] \), as equation (4) shows.
\[ \lambda_i(C_k, \varepsilon_i, D_j, T(\theta^i)) = \int_{p_i} \psi_1 dS_{p_i}(\alpha, \beta, s) \]  

(4)

From these two measurements, Index of Learning Deprivation (ILD) results as a composition of absolute and relative deprivation [13], which is equivalent to adding the intensity functions of all students in \( L_0 \) and weighting the result for all students grouped by \((\varepsilon_i, D_j)\), as equation (5) indicates

\[ n_k(\varepsilon_i, D_j; L_0) \left[ \sum_{r=1}^{m} n_k(\varepsilon_i, D_j; L_r) \right]^{-1} \cdot \frac{1}{L_0} \sum_{i=1}^{L_0} \lambda_i(C_k, \varepsilon_i, D_j, T(\theta^i)) \]  

(5)

From the above, the ILD is given by equation (6)

\[ \delta_k(C_k, \varepsilon_i, D_j, T(\theta^i)) = H_k(\varepsilon_i, D_j) \cdot \Lambda(C_k, \varepsilon_i, D_j, T(\theta^i)) \]  

(6)

4. Deprivation in Socioeconomic Classes Beyond Borders

As the ILD is a standardized and bounded metric, its estimates are useful to compare different groups and countries in a stable way [14], which allows, among other things, to assess the size of the gaps over time and territory. The horizontal axis of Figure 3 shows the rate of learning deprivation \((H_k)\), the vertical axis represents the intensity of learning deprivation \((\Lambda_k)\), both at country level. As can be seen, there is a fairly significant positive correlation between the metrics \((\rho_H, \Lambda = 0.90, p < 0.001)\), i.e., those countries with the highest percentage of students with learning deprivation also tend to exhibit more intense deprivation: in those countries with greater challenges, such as the Dominican Republic, Paraguay, Panama, Peru, Honduras and Nicaragua, not only have more students lacking the most basic education, but the deficiency is broader and deeper, so reducing the gaps with the mixed effect may require greater efforts than those made by other countries in better financial conditions.

Figure 3. Relationship between absolute and relative deprivation.

Figure 4. ILD gaps among countries grouped by SES deciles.
lowest deciles, a close negative relationship between SES and ILD ($\rho_{3_{\text{il},\text{SES}}}= -0.735, p<0.001$) allows to estimate the sizes of the intra-and inter-country gaps, as well as to analyze its intensity, unveiling a structural deprivation beyond borders.

For recognizing the deprivation structure of each country, it might be useful to build a directed weighted network integrating only the students whose scores were located in $L_0$ and relate the nodes that represent the countries with the SES deciles through multiple edges. In this network, each student is an edge such that $\{C_k\} \rightarrow \{D_j\}$, where the $k$-countries are source-nodes and deciles are sink-nodes [15]. By its continuous nature, the normalized value of $\lambda(\cdot)$ is the weight of each edge $E_j$. Figure 5 shows the network of this model where it is possible to find class properties and identify degrees of learning deprivation: from Generalized to Controlled. After iteration process, the In-degree parameters of nodes estimate the level of connectiveness of each node $H_k(D_j)$, represented by the size of the node and pointing out how far from the regional average is each SES-decile.

As can be seen, Honduras, Dominican Republic, Nicaragua, Guatemala and Peru concentrate in low deciles through strong connections, showing generalized deprivation in poorest students, while Panama, Colombia, Mexico and Brazil deprived students are distributed along poor and middle SES; Uruguay, Costa Rica and Chile diversify deprivation in a better way, being Argentina and Chile the more balanced countries, having a better control over SES impact. Furthermore, countries with lower SES also exhibit higher rates of deprivation, with the exception of Panama, which despite having a higher SES level than Ecuador or Peru, exhibits similar deprivation rates as Honduras and Guatemala.

![Network representation of the level of learning deprivation in each country based on the distribution and degree of connectivity of students splatted by deciles and $\delta_k(C_k, D_j)$.](image)

**Figure 5.** Network representation of the level of learning deprivation in each country based on the distribution and degree of connectivity of students splatted by deciles and $\delta_k(C_k, D_j)$.

5. How Big Are the Learning Gaps?

One way to assess the learning gaps between socioeconomic groups is from the speed with which this deprivation changes as the SES varies. In this way, the regression coefficient between deprivation levels and SES is a measure of speed and could indicate the intensity of the gap with respect to socioeconomic status. As has been seen, the countries that present higher absolute levels of deprivation also exhibit higher relative levels of deprivation, however, the intensity of the gaps in both dimensions is a measure that offers novel information on the learning distance that separates students by SES, allowing to estimate the expected effects when applying variational methods to policies.

In this sense, Figure 6 shows a strong exponential relationship ($\rho=0.902, p<0.001$) between the intensity of the absolute and relative deprivation gaps when estimating the regression equation over SES. The results indicate that Chile, Costa Rica and Colombia, exhibits shorter learning distances among their students, when compared to the Dominican Republic and Paraguay, countries that are much less economically capable than Chile, but in which students from the richest families learn the same. In this sense, it is interesting how the intensity of the gap in Panama is one of the largest in the
region—similar to that of Paraguay—, but it is located in the LAC average in the intensity of deprivation.

![Figure 6. Relationship between intensities of absolute and relative deprivation gaps.](image)

![Figure 7. Magnitude of the gaps in each country through odds-ratio D_{01} - D_{10}](image)

To clarify the magnitude of the gaps in each country, the odds-ratio between two deciles \( D_i \) and \( D_j \) in the stratum \( \varepsilon_i \) can be estimated for country \( k \), i.e., the quotient between odds of \( D_{01} \) and \( D_{10} \), denoted by \( \text{OR}_k(\varepsilon_i; D_i, D_j) \), which indexed the size of the gap as a function of how many students from the lowest decile are expected to have in \( L_0 \), for each student from the highest decile. Figure 7 shows the calculation for all countries, the OR in the region is 15 poorest students for each one from the richest families, Chile, Uruguay and Argentina show the smallest gaps, followed by Ecuador and Colombia, being Panama, Mexico, and Brazil those countries with the largest OR highlighting the worst situation in LAC.

6. Discussion

Analyzing the average scores of the countries for estimating the gaps between them, leaves aside the rich qualitative information derived from achievement levels. For attending both key aspects, this research offers a new metric based on the concepts of absolute and relative deprivation to generate robust evidence on the profound lack of equity between different socioeconomic groups, a phenomenon rooted in all LAC countries [16]. Shown results are absolutely relevant because are more and better associated with the SDG-4 and the right to education. This study establishes three milestones in educational research using the best available data. The first one is to provide a direct method for estimating educational deprivation. The second one is to estimate structural inequality by decomposing into regional socioeconomic deciles with comparable measures. The third one is to provide an estimation of the intensity of learning deprivation as a function of SES, producing useful information for helping policymakers to develop an inclusive and equitable education system for all.

7. Conclusion

Most of students with low levels of performance come from poor families living in precarious conditions at home, profound nutritional deficiencies, and little or no access to health systems and employment [17,18]. So, tracking the lack of equality in the students’ right to learn is crucial because it will be reflected later in multiple inequalities, deepening the systematization of precariousness, generating circles of poverty, reducing social mobility and promoting a stronger structural inequality [19], extinguishing the few possibilities of millions of children of developing skills for getting higher opportunities to a better life [20].
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