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What Are the Statistics That Improve Education?

Marta Soler-Gallart [1,*], Dragana Avramov [2], Nancy Zoidou Saripapa [3], Karol Melgarejo [4], Cristian González López [1], María Troya Porras [1], Alba Pistón-Pozo [4], Esther Oliver [1], Mimar Ramis-Salas [1], Javier Díez-Palomar [4] and Garazi Lopez de Aguileta [1]

[1] Department of Sociology, University of Barcelona, 08034 Barcelona, Spain; cristian.gonzalez@ub.edu (C.G.L.); maria.troya@ub.edu (M.T.P.); estheroliver@ub.edu (E.O.); mimarramis@ub.edu (M.R.-S.); glopezdeaguileta@ub.edu (G.L.d.A.)
[2] Population and Social Policy Consultants, 1000 Brussels, Belgium; dragana@avramov.org
[3] KMOP-Social Action and Innovation Centre, 10434 Athens, Greece; saripapa.n@kmop.org
[4] Department of Linguistic, Science and Mathematics Education, University of Barcelona, 08035 Barcelona, Spain; karol.melgarejoa@ub.edu (K.M.); apistopo18@alumnes.ub.edu (A.P.-P.); jdiezpalomar@ub.edu (J.D.-P.)
* Correspondence: marta.soler@ub.edu

Abstract

There is much research on national and international statistical sources on analyses and trends of educational inequalities, which allow for a descriptive and analytical overview of a population's educational status and trends—such as attainment levels, dropout rates, and sociodemographic variables. There is also research that has identified successful interventions across different countries that contribute to overcoming and reversing educational inequalities. However, the research on whether and how national and international statistical sources provide analyses on how to overcome and reverse educational inequalities remains underexplored. This article contributes to filling this gap by critically examining the available national and international statistical sources used in the educational field to analyze whether and how they include the necessary information for assessing the impact of specific educational interventions that overcome inequalities. Drawing on longitudinal and cohort studies within the European project REVERS-ED, the article highlights the need to move towards research models that incorporate explanatory variables and identify which interventions most effectively improve learning outcomes. Findings show that, despite widespread recognition of successful interventions, their impact is rarely reflected in official statistical systems, thereby limiting access to crucial information for teachers, policymakers, and educational institutions. Unlike disciplines such as medicine, education lacks systematic monitoring of the effects of successful interventions, making it difficult to establish clear correlations between them and learning outcomes. This paper advocates for greater accessibility to evaluative data and a shift towards applied, collaborative research that responds to the real needs of citizens, contributing to a more equitable, inclusive, and effective education system.

Keywords: education; educational statistics; learning outcomes; scientific evidence; successful educational actions; applied research; educational policies

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1. Introduction

For decades, governments, institutions, and entities or organizations linked to educational research have been referring to statistical data every time they want to justify the need for a new educational measure, a legislative change, or any other action they

want to carry out in institutional decision-making. While there is considerable research analyzing national or international statistical data to identify trends in education, there is a need to critically examine such sources to determine the extent to which statistics provide sufficient information on educational actions to identify which ones improve students' performance and contribute to overcoming and reversing educational inequalities. In this article, we explore different statistical sources of data on education available. The objective of this article is to discuss whether this type of data provides the necessary and sufficient information for those who must make decisions on what educational action to implement to know which of them produce greater learning and which lead to lower levels of learning.

To advance this debate, it is important to clarify the conceptual distinction between data and statistics, terms that are often used interchangeably but refer to different stages in the process of knowledge generation. Data refers to raw observations or measurements, numerical or categorical, that are collected from individuals, groups, or systems. Statistics, by contrast, are the result of analyzing that data: they transform raw data into summarized information, such as averages, distributions, or correlations, which can then support arguments or guide decision-making (Heiberger and Holland 2015).

Within the field of statistics, two main branches are usually distinguished. Descriptive statistics help us organize and summarize data to understand what is happening in a specific context, using tools such as frequencies, means, or visual representations. Inferential statistics, on the other hand, allow us to draw conclusions about a larger population based on data from a sample (Hahs-Vaughn 2020). Over the decades, scholars have developed a range of tests and instruments grounded in the application of probabilistic laws and the mathematical characterization of trends—such as linear relationships and curves of growth or decline. These instruments take into account whether the data distributions associated with the variables are quantitative and continuous, whether they conform to a normal distribution, whether variances are homogeneous, whether observations are independent, and whether the data fall within the scope of non-parametric cases—namely, those involving non-scalar variables or distributions that deviate from normality. Such tools enable the use of inferential statistics to predict events or identify trends based on population samples. In broad terms, descriptive statistics provide a "snapshot" of the phenomenon under observation, with the level of precision increasing in proportion to the granularity of the available data. Inferential statistics, by contrast, enable the formulation of hypotheses regarding population trends, contingent upon assumptions about the normality (or otherwise) of the data distribution and drawing upon limited samples, which may or may not accurately reflect the broader characteristics of the entire population. Together, these two branches of statistical analysis have made significant contributions across diverse fields of knowledge (Casella and Berger 2024; Flury 1988; Gallant 1987; Jackson and Cox 2013; Von Eye 1990; Stuart and Ord 1999a, 1999b).

This article focuses on the two aforementioned types of statistics as they are employed in the production of statistical series made available by major data providers—such as UNESCO, the OECD, the World Bank, and national statistical agencies—as well as in studies published in specialized academic journals and repositories that disseminate findings from educational research. Our aim is to examine whether these available statistical data offer sufficient information to accurately assess the impact of specific educational interventions on student learning, or whether they merely provide a (more or less detailed) profile of the study population without shedding light on the outcomes resulting from practitioners' decisions to implement particular pedagogical strategies in the classroom. To this end, we will distinguish, within the framework of this article, between statistics that serve to describe the characteristics of the population under study and those that yield information capable of generating what Van den Besselaar et al. (2018) term "social impact"—that is,

statistics that reveal concrete improvements in learning outcomes attributable to specific educational actions.

This distinction is particularly relevant in the field of education, where decision-makers need to understand not only the current situation but also whether a particular policy or practice yields measurable effects. Thus, using statistics effectively requires not only the collection of appropriate data, but also an understanding of the kind of analyses that can be performed and their purposes.

Currently, the use of scientific evidence as a basis for decision-making is becoming increasingly prominent in the field of education (Flecha 2014). Scientific projects funded by the European Commission's Framework Programme of Research such as INCLUD-ED (2006–2011), IMPACT-EV (2014–2017), ALLINTERACT (2020–2024) and now also REVERS-ED (2024–2027) show that the trend at the international level is for research to be placed at the service of citizenship and to work, in co-creation—understood as the creation of knowledge in continuous dialog between researchers and citizens (Crespo-López et al. 2025; Ruiz-Eugenio et al. 2021), to identify needs and the contributions that research can make to respond to those needs.

In the field of education, citizenship demands are articulated through instruments such as the Sustainable Development Goals (SDGs). This set of goals, proposed by the United Nations (2016), seeks to transform the world into a more just, inclusive, and sustainable place by 2030. Specifically, SDG 4, Quality Education, highlights that education is a fundamental human right, and is vital for social progress and equity. There are previous studies that have focused on investigating how education serves to reverse educational inequalities, which, in turn, are closely associated with social inequalities in the medium and long term. Studies such as those by Alexiu et al. (2010), Kingston et al. (2003), Lövdén et al. (2020), and Raghupathi and Raghupathi (2020) show that education has a profound impact on people's life chances by improving their career opportunities, health, and social outcomes. For example, OECD (2023a) provides data showing that people with higher levels of education also have higher wages. On average, young adults with bachelor's degrees earn 29% more than those with upper secondary education, while those who completed short-cycle tertiary education earn, on average, 13% more, in addition to showing better rates of health and well-being. The study by Murtin et al. (2017) points out that people with an education level 1, i.e., who have completed only primary education, or those with a level below 1, have worse health levels and their life expectancy is significantly lower compared to people with a higher level of education. This gap in life expectancy between people with high and low levels of education is, on average, 8 years for men and 5 years for women at age 25, and 3.5 years for men and 2.5 years for women at age 65.

On the other hand, student performance at different educational levels is related to the level of studies they eventually complete. Studies such as those by Kunnari et al. (2023) and Pustjens et al. (2004) demonstrate the significant influence of secondary schools on students' academic decisions. Likewise, Rabiner et al. (2016) highlight that early academic skills and other non-cognitive factors, such as attention and social competence, are strong predictors of future academic performance. For similar reasons, organizations responsible for large-scale surveys, such as PISA and PIAAC, are increasingly emphasizing the urgent need to raise the average educational attainment levels of the population (Kirsch et al. 2025).

All this shows that education, educational attainment, and learning outcomes are critical variables in reducing social inequalities and enhancing life opportunities and well-being, particularly for the most vulnerable populations. In fact, society also benefits from this: the OECD (2020) indicates that investment in secondary education generates an average annual rate of return of 6% for men and 3% for women, resulting in an economic return for governments, as better-educated workers have higher incomes and, therefore,

a greater fiscal contribution. Additionally, in the long run, social spending decreases as dependence on social assistance programs declines. Research provides substantial evidence on the impact of educational actions and interventions on learning outcomes. In this sense, "good practices" are interventions based on assumptions and good intentions, which are founded on the idea of simply doing something different to solve the problem, without prior evidence that this action has proven effective in other contexts (Flecha 2015). In contrast, the Successful Educational Actions (SEA), identified in the INCLUD-ED research project (2006–2011), have been demonstrated, with rigorous scientific evidence, to be actions that generate excellent results for students from diverse contexts, enabling the promotion of instrumental learning and the improvement of school coexistence, thus contributing to the reduction in social inequalities (Elboj-Saso et al. 2021; Roca et al. 2024; Campdepadrós-Cullell and De Botton 2021).

For instance, interactive groups have been shown to enhance academic performance in areas such as mathematics and foreign language learning while also fostering collaboration, solidarity, and mutual support among peers (Díez-Palomar and Cabré 2015; Valls and Kyriakides 2013). Similarly, dialogic gatherings have demonstrated an increase in critical thinking, reasoning skills, prosocial behaviors, and interest in reading (Ruiz-Eugenio et al. 2021; Roca-Campos et al. 2024; Lopez de Aguileta 2019). Just like the extension of learning time, through learning activities outside the classroom, improves educational performance and promotes the well-being of boys and girls, this is especially significant for vulnerable populations, as it helps mitigate the risks associated with poverty and/or social exclusion (Flecha 2015).

Although there is extensive scientific evidence on the social impacts (Van den Besselaar et al. 2018) of educational actions and interventions that improve learning outcomes, there is a need for more publicly available data that show, with quantitative evidence, that this is true. In this sense, statistics (especially descriptive statistics) would be an excellent instrument to make visible the impact of concrete educational actions.

At the international level, we have major surveys that measure the level of performance in certain areas of knowledge. One of these surveys, perhaps the best known, is the Programme for International Student Assessment (PISA), which examines how well 15-year-old students nearing the end of compulsory education have acquired the knowledge and skills needed to participate in the labor market and society. It focuses on key subjects such as reading, mathematics, and science (OECD 2023b).

In PISA, we find a series of independent variables that are used to "explain" learning results in reading comprehension and mathematics (mainly, although in each cycle, some other competency is added). These variables have to do, on the one hand, with the student him/herself, and on the other hand, with the school.

When focusing on the student, PISA, for example, collects data on factors such as gender, grade repetition, immigrant status, access to a cell phone with internet, the availability of books at home -and their quantity-, the presence of a quiet work space, preschool attendance, reading habits for leisure, and their socio-cultural level (ISEC). Regarding the school, PISA includes the following independent variables: the ownership of the school (whether it is public or private), the location (rural or urban), the size of the class, extracurricular activities, and students' satisfaction with his or her relationship with the teachers.

Different studies have created explanatory models using some(s) of these variables, to see what is the impact of aspects such as gender, background, classroom size (the ratio) or whether or not one has books at home, on the results achieved in mathematics and reading (Daniele 2021; Sánchez et al. 2019; Schnell and Azzolini 2015; Stoet and Geary 2013; Martins and Veiga 2010).

In addition, some schools and governments in certain countries do measure and have data on student performance according to the type of educational actions implemented in schools (although this information is often in the domain of the educational inspectorate, and it is not usually made public, hence it is not possible for researchers, neither for citizens or other end-users, to know the impact of a particular action in improving (or not) students' educational performance).

Thus, looking at educational studies drawing on the use of statistics, it seems clear that we have a plethora of statistical instruments (descriptive measures, such a mean, median or mode, inferential such as different types of tests using linear regression drawing on the least squares method, or non-linear regression models, for example) that can be used to describe ("take a photo") or figure out (according to certain levels of uncertainty) trends or events.

However, there is a lack of methodological research examining the statistical instruments themselves and the data they produce, particularly in relation to how these sources of information are constructed and whether they provide the type of evidence needed to support informed decision-making regarding the implementation of educational interventions in the classroom. In this article, we explore and critically analyze a purposely selected set of the main sources of statistical data currently available in the field of education, with the aim of assessing the nature of the data they offer and the extent to which such data can inform efforts to achieve broader social objectives, such as those outlined in the Sustainable Development Goals (SDGs).

2. Materials and Methods

The focus of this article is the statistical sources utilized in the education sector to analyze the learning outcomes of various educational levels within the population. The study is framed by the REVERS-ED project, which is funded by the European Commission's Horizon Europe Framework Programme of Research. In its initial phase, this study emphasizes the investigation and analysis of longitudinal data sources and cohort studies in education. The primary aim of these sources is to observe the dynamics within a specific population, achieved by selecting samples that meet various statistical criteria. Research utilizing such sources in education often includes variables like school dropout rates, academic performance, and proficiency levels across different subjects (e.g., reading, writing, mathematics, science, etc.). Through a series of questions related to what is typically termed "sociodemographic data," these studies aim to furnish a sociological description of the distribution of these social variables in relation to the subjects being examined (such as the aforementioned variables). To achieve this, surveys are conducted among graduates and dropouts, who are employed to illustrate the educational outcomes of a sample at a particular time and place. Additionally, there are comparative studies that gather similar data from different cohorts and subsequently analyze them in relation to one another.

Longitudinal data can be obtained from different sources and using different data collection methods. The most commonly used method is questionnaires with questions that are repeated over time, to the same cohort of people, prospectively. A sample of the cohort is taken and followed over time, collecting data at specific points in time. Both questionnaires and other types of methodological instruments (interviews, collection of documentation, discussion groups, etc.) are used over time.

2.1. Research Questions

In this study, we address three research questions: (RQ1) What statistical sources are available for longitudinal analysis of the learning outcomes of a population over time? (RQ2) What kind of information do these statistical sources provide for longitudinal

analysis of the learning outcomes of populations? The data provided by existing statistical sources offers the potential to inform decision-making. Thus, the third research question that we address in this article is: (RQ3) To what extent can these data enable us to identify which educational interventions are likely to enhance learning outcomes for specific target populations over time?

2.2. Research Design

To address these three research questions, we have conducted an exploratory study of national and international statistical sources. REVERS-ED examines trends in educational outcomes and inequalities over time for three cohorts of students: those born in 1999, 2004, and 2009. In the first two cases, the analysis period includes primary and secondary education (cohort 1: 2005–2017 and cohort 2: 2010–2022). In the third case, the analysis primarily focuses on primary education due to research time constraints, as only complete data for the primary stage (2015–2021) will be available for those born in 2009, since secondary education is still ongoing during this research. Table 1 summarizes the three cohorts examined.

Table 1. Definition of study cohorts.

Study Cohort	Students Born in the Year	Period of Analysis	Years of Schooling Covered
Cohort 1	1999	2005–2017	Primary and secondary education
Cohort 2	2004	2010–2022	Primary and secondary education
Cohort 3	2009	2015–2021	Primary education

2.3. Collection of Data Sources

First, the data variables to be collected were defined. For this purpose, the framework established by the Sustainable Development Goals was taken as a reference, as an expression of the demands of global citizenship in the field of education (SDG 4). This approach was adopted because the SDGs offer a globally recognized and comprehensive framework for addressing education challenges, particularly in terms of quality and equity. In REVERS-ED, trends in educational outcomes and inequalities are defined based on the demands of society. For this reason, the SDGs serve as criteria to inform the project's goals and indicators. The fourth SDG refers to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all." This goal is deployed in a series of targets and indicators (see Table 2).

Table 2. SDG 4 targets and indicators.

Target	Indicators
T4.1. By 2030, ensure that all girls and boys complete free, equitable, and quality primary and secondary education leading to relevant and effective learning outcomes	I4.1.1. Proportion of children and young people (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex
	I4.1.2. Completion rate (primary education, lower secondary education, upper secondary education)
By 2030, ensure that all girls and boys have access to quality early childhood development, care, and pre-primary education so that they are ready for primary education.	I4.2.1. Proportion of children aged 24–59 months who are developmentally on track in health, learning, and psychosocial well-being, by sex

Table 2. *Cont.*

Target	Indicators
	I4.2.2. Participation rate in organized learning (one year before the official primary entry age), by sex
T4.3. By 2030, ensure equal access for all women and men to affordable and quality technical, vocational, and tertiary education, including university education	I4.3.1. Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex
T4.4. By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship	Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill I4.4.2.
By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples, and children in vulnerable situations.	I4.5.1. Parity indices (female/male, rural/urban, bottom/top wealth quintile, and others such as disability status, indigenous peoples, and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated
T4.6. By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.	I4.6.1. Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex.
T4.7. By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	I4.7.1. Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education, and (d) student assessment
T4.a. Build and upgrade education facilities that are child, disability, and gender sensitive and provide safe, non-violent, inclusive, and effective learning environments for all	I4.a.1. Proportion of schools offering basic services, by type of service

Based on this approach, all members of the REVERS-ED consortium compiled the sources of education statistics in their respective countries. With this information, a database was constructed, mainly at the European level, where the sources and variables of these sources were entered. As a first step in this process, an initial matrix was created to systematically organize the collected data, ensuring consistency across countries and cohorts. This matrix served as the basis for structuring the final database and facilitating further analysis (see Table 3).

This information was then organized based on two criteria: (a) to respond to the objective of the REVERS-ED project, which aims to reverse educational inequalities; and (b) to use the indicators of the SDGs (specifically, SDG 4) to organize the variables according to the targets outlined in these objectives, as specified in Appendix A. In both cases, the selection criterion was always the available data corresponding to the three study cohorts: those born in 1999, 2004, and 2009. Appendix A illustrates this initial selection of data. This table shows the available data sources for each of the considered countries and the indicators for which data exists for SDG 4, along with the time series adjusted to the three age groups mentioned, as shown in Table 1.

Table 3. REVERS-ED database to compile the education indicators for the three study cohorts (initial version).

Models of What the Working Matrix and the Final Matrix Would Look Like with the Desired Welfare Outcomes, With and Without Foreign Students.													
Working Matrix (It Is Bigger Than the Other One Because Here Are the Years of Each Cohort)						**Final Matrix with the Searched Results on Welfare (The Information Has Been Compressed)**							
Cohort	**Country**	**Educational Level**	**Year**	**Educational Outcomes ***	**Socioeconomics +**	**Structuring Data**			**Quantitative Results**			**Binary Results to Compare the Correlation**	
1999	Belgium	Primary	2005	N/A	N/A	Cohort	Country	Educational Level	Edu. Results (No Foreign) (%)	Edu. Results (with Foreigners) (%)	Socioeconomy (%)	Edu. Success ≥50% (No Foreigners)	Edu. Success ≥ 50% (with Foreigners)	Resources >= at 50%?
1999	Belgium	Primary	2006	N/A	N/A	1999	Belgium	Primary	20	35	50	FALSE	FALSE	TRUE
1999	Belgium	Primary	2007	N/A	N/A	1999	Belgium	Lower	32	25	75	FALSE	FALSE	TRUE
1999	Belgium	Primary	2008	N/A	N/A	1999	Belgium	Upper	59	50	77	TRUE	TRUE	TRUE
1999	Belgium	Primary	2009	N/A	N/A	2004	Belgium	Primary	55	60	25	TRUE	TRUE	TRUE
1999	Belgium	Primary	2010	N/A	N/A	2004	Belgium	Lower	30	20	50	FALSE	FALSE	TRUE
1999	Belgium	Lower secondary	2011	N/A	N/A	2004	Belgium	Upper	15	27	49	FALSE	FALSE	FALSE
1999	Belgium	Lower secondary	2012	N/A	N/A	2009	Belgium	Primary	75	70	24	TRUE	TRUE	FALSE
1999	Belgium	Lower secondary	2013	N/A	N/A	2009	Belgium	Lower	32	25	84	FALSE	FALSE	TRUE
1999	Belgium	Lower secondary	2014	N/A	N/A									
1999	Belgium	Upper secondary	2015	N/A	N/A									
1999	Belgium	Upper secondary	2016	N/A	N/A	2009	Belgium	Upper	59	51	74			
2004	Belgium	Primary	2010	N/A	N/A	1999	Bulgaria	Primary	55	60	42	TRUE	TRUE	TRUE
2004	Belgium	Primary	2011	N/A	N/A	1999	Bulgaria	Lower	20	30	75	TRUE	TRUE	FALSE
2004	Belgium	Primary	2012	N/A	N/A	1999	Bulgaria	Upper	15	27	77	FALSE	FALSE	TRUE
2004	Belgium	Primary	2013	N/A	N/A	2004	Bulgaria	Primary	75	70	25	FALSE	FALSE	TRUE
2004	Belgium	Primary	2014	N/A	N/A	2004	Bulgaria	Lower	32	25	50	TRUE	TRUE	FALSE
2004	Belgium	Primary	2015	N/A	N/A	2004	Bulgaria	Upper	59	51	49	FALSE	FALSE	TRUE
2004	Belgium	Lower secondary	2016	N/A	N/A	2009	Bulgaria	Primary	55	60	24	TRUE	TRUE	FALSE
2004	Belgium	Lower secondary	2017	N/A	N/A	2009	Bulgaria	Lower	20	30	84	TRUE	TRUE	FALSE

* Educational outcomes include: repetition rate (%), completion rate (%), foreign students (%), students with special educational needs (SEN) (%), dropout rate (%), and retention rate (%).
+ Socioeconomic indicators include: risk of poverty (%), unemployment rate (%), child poverty rate (%), and access to technology (%)

Due to the great disparity of the available data, because they come from different sources, and in many cases are presented either as point data (per student) or as percentage data (percentages), it was decided to group the data according to the source of origin. In this sense, a distinction is made between international sources and national sources. In the case of international sources, which are common to all European countries analyzed, the data are grouped according to the following sources:

- UNESCO (UIS browser);
- OECD (PISA, TIMSS, and PIRLS);
- Europe (Education at a glance, OECD Data explorer, Eurostat Database);
- World Bank (World Bank Open Data).

These internationally recognized sources have been selected based on their rigorous data collection standards, which reinforce the validity of this information. From within these statistical data sources, we selected a number of indicators that the respective organizations themselves employ to describe, study, or analyze educational inequalities, as outlined in their technical reports. The selected indicators are presented in Table 4. The selection process primarily focused on variables related to educational attainment, student performance (in the subjects covered by these data sources), enrolment and dropout rates, as well as structural indicators such as educational expenditure, student–teacher ratios, school resources, and relevant sociodemographic characteristics.

Table 4. Selection of indicators for each of the sources used.

Source	Indicators
UNESCO	Achieving in mathematics (%) Achieving in Reading (%) both sexes Students experiencing bullying last 12 months (%) Attacks on students, personnel, and institutions (number of) Pupil-qualified teacher ratio (headcount basis) Students who have their first or home language as the language of instruction, both sexes (%) Total aid to education allocated to least developed countries (%) Initial government expenditure on education as a percentage of GDP (%) Initial private expenditure on education (household) as a percentage of GDP (%) Expenditure on education (public, households, ODA) as a percentage of GDP (%)
OECD—PISA	Science (average) Reading comprehension (average) Mathematics (average) Students with better results in at least one subject—level 5 or 6 (%) Pupils performing below level 2 in science (%) Students with low performance in the three subjects—below level 2 (%) Variation in science achievement explained by student socioeconomic status (%) Difference in science score associated with a one-unit increase in ESCS (score diff.) Between-school variation in science performance explained by student and school ESCS (%).
OECD—TIMSS	Average Achievement (Mathematics & Science) Average Achievement by content and cognitive domain, and by gender School Resources and Environment: Resource shortages, academic emphasis, discipline, safety/order, bullying, socioeconomic composition Language and Early Preparation: language spoken at home, preprimary attendance, early preparation, entry-level skills Home Learning Resources: Learning materials at home, early literacy and numeracy activities Teachers and School Leadership: Education, experience, job satisfaction, professional development participation, and needs Access and use of computers, testing on digital devices

Table 4. *Cont.*

Source	Indicators
Eurostat	Enrollment of children Enrollment of girls Total enrollment Completion of children Completion of girls Total completion Dropout rate (%) Total poverty risk (%) Risk of poverty in children under 18 years of age (%) Investment in education (million euros) Education expenditure as a percentage of GDP (%)
World Bank	Adjusted net enrollment rate (%) Adolescents and children out of school (%) Secondary education, vocational pupils, total and both sexes Secondary education, general pupils, total and both sexes School enrollment, primary and secondary (gross), gender parity index (GPI), total, and both sexes Repeaters, primary, total, and both sexes (% of total enrollment) Pupil-teacher ratio Persistence to grade 5, total and both sexes (% of cohort) Expenditure on education (% of government expenditure on education) Adjusted savings: education expenditure (current US$) Adjusted savings: education expenditure (% of GNI) Poverty headcount ratio at societal poverty line (% of population) Poverty headcount ratio at national poverty lines (% of population)

The data mentioned in Table 4 were then extracted, generating a data folder for each country and for each source.

In addition, where available, statistical data on education produced by official bodies—such as National Statistics Institutes—were incorporated into the matrix. These data, which are typically census-based, also include national assessment results from each country's education system. For instance, they comprise performance data across various subjects and academic years, which governments utilize to evaluate students' educational attainment throughout their academic trajectories. In the case of each country, recourse is always made to official sources of statistical data on education (mainly the corresponding national statistical agencies or the administrative body responsible for educational evaluations). Tables 5–8 illustrate the data matrix generated for each source and some of the selected variables.

Finally, a data matrix was created, organized according to variables and sources. This matrix was refined taking into account (a) the overall objective of the project REVERS-ED, and (b) the indicators of the different targets associated with SDG 4.

2.4. Data Analysis

To answer RQ1, an exploratory analysis of the selected sources was carried out. For each of the age groups (1999 cohort, 2004 cohort, and 2009 cohort), a matrix was constructed in EXCEL. The data extracted from the various statistical sources on education (see Table 4) were organized longitudinally in a matrix structure, according to three age cohorts (see Tables 5–8). The columns of this matrix correspond to the variables outlined in Table 3, into which the respective time series data were integrated. Additionally, the matrix included the variable "educational level," referring to the highest level of education completed—namely, primary, lower secondary, and upper secondary education. Due to the disparities between educational systems in different countries, the ISCED criterion was used to standardize

the data. The information compiled in this matrix has been used to address Research Question 1 (RQ1) by identifying the data available for the three selected cohorts and analyzing the insights these data provide regarding the educational experiences of these groups (longitudinal analysis over time).

To address Research Question 2 (RQ2), we explored the possibility of integrating data from multiple sources to construct a longitudinal analysis of the learning outcomes of the three cohorts. This necessitated careful consideration of the nature of the data provided by each source, as the datasets were not always directly comparable. Where feasible, we aimed to standardize the data; however, in instances where standardization was not possible, alternative methodological approaches—primarily of a more qualitative nature—were employed to account for and respect the differences inherent in each data source. To answer RQ2, we considered the nature of the data from each of the sources. In the case of the statistical data from the OECD, the dataset (microdata) was accessed, and the statistical package SPSS (30.0.0.0 (171)) version was used to obtain the data for each of the variables. The data correspond to responses per student participating in each of the surveys (PISA, TIMSS, PIRLS, and PIACC). The data from UNESCO, Eurostat, and the World Bank are aggregate data, presented as percentages. The disparity in the nature of the data among the different sources compelled us to perform (1) a univariate descriptive statistical analysis for each of the sources used, (2) select some variables that could be crossed within each data source, and conduct a general bivariate analysis (crossing of two variables) to see the percentages of co-occurrence, and (3) a qualitative comparison of the results obtained across the sources, globally. In some cases of the bivariate analysis performed with data from the same data source, a predictive model was also created using the least squares method and the best fit to the regression line, while calculating the uncertainty of the slope. In all cases, the data from the three time series corresponding to the three age groups studied were utilized, as long as this data existed for the relevant year.

Table 5. Sample of data extracted from Eurostat for one of the countries in the REVERS-ED consortium.

Country	Cohort	Educational Level	Year	Age	Boys' Enrolment	Girls' Enrollment	Total Enrolment	Risk of Poverty (%)	Risk of Poverty Children Under 18 (%)	Investment in Education (Million Euros)	Education Expenditure (GDP %)
Belgium	1999	Primary	2005–2006	6–7	55,507	54,472	109,979	ND	ND	ND	1.40
Belgium	1999	Primary	2006–2007	7–8	59,605	57,023	116,628	ND	12.2	ND	1.41
Belgium	1999	Primary	2007–2008	8–9	59,880	57,339	117,219	ND	13.3	ND	1.41
Belgium	1999	Primary	2008–2009	9–10	60,191	57,578	117,769	ND	14.4	ND	1.53
Belgium	1999	Primary	2009–2010	10–11	60,468	57,843	118,311	ND	11.7	ND	1.5
Belgium	1999	Primary	2010–2011	11–12	59,859	57,149	117,008	ND	14.8	ND	1.55
Belgium	1999	Lower secondary	2011–2012	12–13	45,786	45,746	91,532	21	14.3	ND	2.8
Belgium	1999	Lower secondary	2012–2013	13–14	59,039	56,491	115,530	21.6	12.8	3672.70	ND
Belgium	1999	Upper secondary	2013–2014	14–15	38,956	40,979	79,935	20.8	13.3	7561.7	ND
Belgium	1999	Upper secondary	2014–2015	15–16	54,300	53,813	108,113	21.2	13.2	7619.5	ND
Belgium	1999	Upper secondary	2015–2016	16–17	57,898	57,068	114,966	21.1	13.9	7734.70	ND
Belgium	1999	Upper secondary	2016–2017	17–18	57,579	56,663	114,242	20.9	14	7866.40	ND
Belgium	1999	Upper secondary	2017–2018	18–19	NA	NA	NA	20.6	13	8070.10	ND
Belgium	2004	Primary	2010–2011	6–7	55,794	54,706	110,500	ND	14	ND	1.55
Belgium	2004	Primary	2011–2012	7–8	59,852	57,330	117,182	21	14.3	ND	1.53
Belgium	2004	Primary	2012–2013	8–9	60,300	57,750	118,050	21.6	12.8	6231.30	ND
Belgium	2004	Primary	2013–2014	9–10	60,559	57,965	118,524	20.8	13.3	6311.80	ND
…	…	…	…	…	…	…	…	…	…	…	…

Table 6. Sample of data extracted from UNESCO for one of the countries in the REVERS-ED consortium.

Country	Cohort	Educational Level	Year	Age	Achieving in Mathematics (%) Both Sexes	Achieving in Mathematics (%) Both Sexes—Rural	Achieving in Mathematics (%) Both Sexes—Urban	Achieving in Mathematics (%) Both Sexes—Immigrant	Achieving in Mathematics (%) Both Sexes—Poor Socioeconomic Background
Bulgaria	1999	Pre-Primary	2005–2006	6–7					
Bulgaria	1999	Primary	2006–2007	7–8					
Bulgaria	1999	Primary	2007–2008	8–9					
Bulgaria	1999	Primary	2008–2009	9–10					
Bulgaria	1999	Primary	2009–2010	10–11					
Bulgaria	1999	Lower Secondary	2010–2011	11–12					
Bulgaria	1999	Lower Secondary	2011–2012	12–13					
Bulgaria	1999	Lower Secondary	2012–2013	13–14	56.24				
Bulgaria	1999	Upper Secondary	2013–2014	14–15					
Bulgaria	1999	Upper Secondary	2014–2015	15–16					
Bulgaria	1999	Upper Secondary	2015–2016	16–17					
Bulgaria	1999	Upper Secondary	2016–2017	17–18					
Bulgaria	1999	Upper Secondary	2017–2018	18–19					
Bulgaria	2004	Pre-Primary	2010–2011	6–7					
Bulgaria	2004	Primary	2011–2012	7–8					
Bulgaria	2004	Primary	2012–2013	8–9					
Bulgaria	2004	Primary	2013–2014	9–10					
Bulgaria	2004	Primary	2014–2015	10–11					
Bulgaria	2004	Lower Secondary	2015–2016	11–12					
…	…	…	…	…	…	…	…	…	…

Table 7. Sample of data extracted from the Generalitat de Catalunya for the case of Spain (Catalonia), the framework of the REVERS-ED project.

SPAIN	Cohort	Educational Level	Year	Age	Enrollment (Non-Compulsory)—No. Students	Non-Compulsory Enrollment Rate	Repetition Rate—Total	Public School Repetition Rate	Private School Repetition Rate	Promotion Rate (Based on Enrolled Students)—Total	Public Promotion Rate (per Enrollment)
Catalonia	1999	Early childhood education	2000–2001	1	15.940	26.5					
Catalonia	1999	Early childhood education	2001–2002	2	30.175	49.3					
Catalonia	1999	Early childhood education	2002–2003	3	181.397	99.3					
Catalonia	1999	Early childhood education	2003–2004	4	190.990	99.4					
Catalonia	1999	Early childhood education	2004–2005	5	198.705	98.4					
Catalonia	1999	Primary	2005–2006	6			1.5	1.9	0.8		
Catalonia	1999	Primary	2006–2007	7			1.6	1.9	1.1		
Catalonia	1999	Primary	2007–2008	8			1.1	1.2	0.9		
Catalonia	1999	Primary	2008–2009	9			1.4	1.6	1.1		
Catalonia	1999	Primary	2009–2010	10			1	1.2	0.9		
Catalonia	1999	Primary	2010–2011	11			1.2	1.2	1.3		
Catalonia	1999	Lower secondary	2011–2012	12			6	7.6	3.3	67.9	62
Catalonia	1999	Lower secondary	2012–2013	13			6.1	7.8	3.3	63	56.4
Catalonia	1999	Lower secondary	2013–2014	14			6.1	7.9	3.2	60.3	53.1
…	…	…	…	…	…	…	…	…	…	…	…

Table 8. A sample of data extracted from the World Bank for the case of Spain, the framework of the REVERS-ED project.

Country	Cohort	Educational Level	Year	Age	Adjusted Net Enrollment Rate, Primary (%)	Adjusted Net Enrollment Rate, Primary, Female (%)	Adjusted Net Enrollment Rate, Primary, Male (%)	Adolescents out of School (% of Lower Secondary School Age)	Adolescents out of School, Female (% of Female Lower Secondary School Age)
Spain	1999	Primary	2005–2006	6					
Spain	1999	Primary	2006–2007	7	99.83884				
Spain	1999	Primary	2007–2008	8					
Spain	1999	Primary	2008–2009	9					
Spain	1999	Primary	2009–2010	10					
Spain	1999	Primary	2010–2011	11					
Spain	1999	Lower secondary	2011–2012	12				1.443889976	1.387030005
Spain	1999	Lower secondary	2012–2013	13				2.105979919	2.024679899
Spain	1999	Lower secondary	2013–2014	14				2.346560001	2.132250071
Spain	1999	Lower secondary	2005–2006	15				2.625780106	2.434959888
Spain	1999	Upper secondary	2006–2007	16					
Spain	1999	Upper secondary	2007–2008	17					
Spain	1999	Upper secondary	2008–2009	18					
Spain	2004	Primary	2010–2011	6					
Spain	2004	Primary	2011–2012	7					
Spain	2004	Primary	2012–2013	8					
Spain	2004	Primary	2013–2014	9	99.60787				
…	…	…	…	…	…	…	…	…	…

Finally, to respond to RQ3, data on proficiency levels in certain areas, such as reading, reading comprehension, mathematics, and science, were obtained (from international studies conducted by the OECD or from regional assessment programs carried out by the educational administrations of the countries participating in the study). A descriptive analysis of this type of data has been carried out. In the case of the international sources, the data allowed us to cross-reference proficiency levels with variables such as socioeconomic level, type of school, student-teacher ratio, public and/or private investment as a percentage of GDP, students who experience bullying, and student background (whether or not they are migrants, and whether or not their home language is the same as the language used at school).

3. Results

The results obtained, in accordance with the proposed research questions, are presented and discussed below.

3.1. Subsection Sources for the Cohort Longitudinal Study of Educational Trajectory (RQ1)

Statistics, defined as data science, has been used mainly in two ways: either (a) to describe phenomena in our environment from a series of observational variables, or (b) to infer characteristics or behaviors of those phenomena from the generation of models using probability.

In the first case, statistics have made it possible to describe objects of study through the observation of items that are defined so they can be examined in detail. In the field of education—covering teaching and learning, social relations in the classroom or at the center, behavior, human and material resources, and other aspects linked to the functioning of educational systems and the acquisition of knowledge—statistics are often used for diagnostic purposes. This means it allows us to know variables such as "number of students enrolled," "level of studies completed," "repetition rate," "school dropout rate," "level of learning in mathematics," "level of reading comprehension," and "percentage of school success according to public spending," among other similar variables. The sources we have consulted, for instance, provide descriptions such as the following:

Based on Eurostat and UNESCO data, we can see that the data show that in a large number of European countries, there are variations between the three age groups studied. Some countries, such as Greece, Ireland, Italy, Lithuania, Portugal, or Romania, show changes in their educational systems, which implies a transformation in the way they approach the various stages of training. In Spain and Italy, for example, the data indicate that there has been a significant growth in enrollments (an increase of 32% in the 2009 generation), driven by the increase in the immigrant population and by the increase in enrollment in the upper secondary stage. The data indicate that there is also a gender balance: there is generally parity in enrollment, except for a few cases, such as Finland, where there is a decline in enrollment of young men. The data also indicate that in terms of school dropouts, there has been a significant decrease between the trends for students in the 2004 cohort and those born in 2009. The educational stage completion rate has improved by 25%. Reductions in school dropout rates are recorded in countries such as Italy, while in others, such as Romania or Bulgaria, school dropout remains a challenge.

As can be seen, statistical data serve to describe the functioning of educational systems, allowing us to observe how they operate and whether they effectively ensure that young people and adults receive the training we expect (which is defined by levels, such as those used in the ISCED). This type of data is usually "census" data, meaning it provides a snapshot per "student" of the education systems, and the databases typically contain the results for all students enrolled in the various educational stages of the countries. Both

Eurostat and UNESCO present their tables using percentages; however, these percentages derive from data provided by the countries and are census data (per student).

Statistical data also serve to provide us with information on learning outcomes (students' proficiency levels). By this, we mean descriptions such as the following:

Data from studies such as PISA, TIMSS, or PIRLS indicate that in recent years, there has been a notable decline in performance in mathematics, reading, and science. Figure 1 illustrates a clear generalized decline in these three competencies in OECD countries (Figure 1).

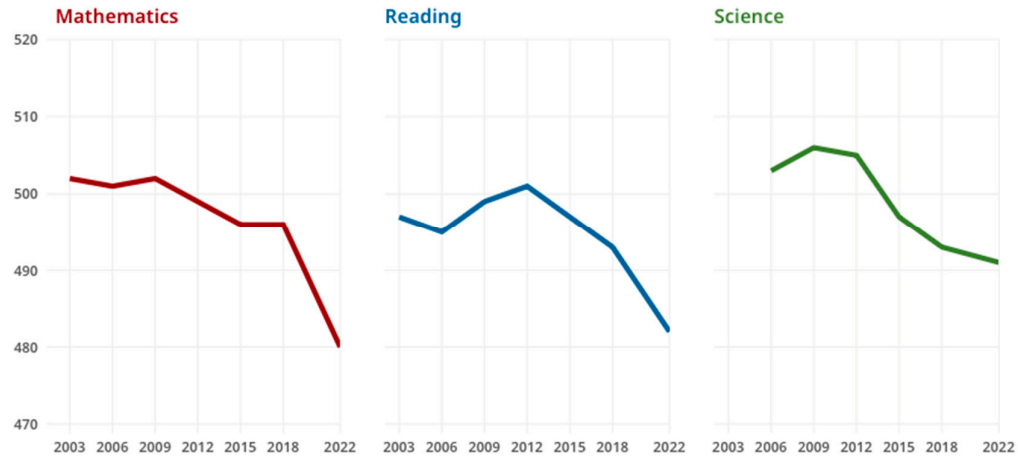

Figure 1. Trends in mathematics, reading, and science performance (OECD average). Source: OECD (2023b). PISA 2022 Results (volume I): The state of learning and equity in education.

Countries such as the Netherlands, Ireland, or Belgium show averages above the OECD average (472 points). However, there are also other European countries that are well below (such as Greece, Croatia, Malta, or the Slovak Republic, for instance).

Second, data like this also allow us to diagnose what is happening in terms of learning within the education systems of different countries. However, unlike the previous sources, this type of data is more limited for several reasons. On one hand, data are only available for the countries participating in these international studies. Although they are international, not all countries take part. Additionally, it is possible that not all countries participate in every survey cycle. Some countries may not have participated in certain cycles, further limiting the available data. On the other hand, the cycles are not annual but typically occur every few years (e.g., PISA is conducted every three years). This results in gaps where no data are available, making it challenging to perform a longitudinal study. Finally, and perhaps most importantly, these are not "census" data but sample data. This means that the learning outcomes in the data matrices correspond to samples (which have adhered to strict statistical criteria for their selection); however, as the name suggests, they reflect data from a sample of the population, not from the entire population. Therefore, we are subject to potential sampling errors that can affect the results, introducing uncertainty in the form of margins of error and confidence intervals for the presented data. Nevertheless, the selection of the samples is sufficiently reliable, allowing these studies to provide a reasonably accurate diagnosis of the situation regarding learning in mathematics, reading, and science.

Third, both census data and sample data allow us to perform multivariate analyses in which we can cross-reference several variables to see what happens, for example, with the dropout rate of migrant schoolchildren, or what happens in mathematics learning according to the socioeconomic class to which the student's family belongs, or if there are differences in enrollment rates between urban and rural environments, and the same

in terms of transition between educational stages. In the data offered by each and every one of the sources we have included in this study, we can cross-reference data to further refine the description of our observations. PISA, for instance, even allows us to observe the differences in performance in mathematics, science or reading comprehension according to whether the family has an Internet connection, whether or not they have a computer at home, or even the number of books in the home (although educational research has widely denied that there is any relationship between having books at home and reading comprehension, because that does not mean that they are read). The difficulty arises when we want to compare data from different sources, because if we do not have the same sample (the same individuals), it is not possible to make a statistical comparison of the data. This greatly limits the possibility of a longitudinal study and forces us to use other approaches, such as a strictly "qualitative" comparison of data, through the trends they indicate.

Finally, in most European countries where we conducted the REVERS-ED research, educational administrations have assessment systems that periodically evaluate the learning outcomes of students. Monitoring typically occurs every academic year at pre-established levels. For example, in Catalonia, one of the regions with educational autonomy in Spain, the Catalan government conducts "diagnostic" tests in the sixth year of primary school and in the fourth year of secondary school. This kind of data is also census-based, meaning all students enrolled in the educational system must take the tests. This allows for longitudinal tracking of specific cohorts over the years. Because it is census-based, the population experiences "inflows" and "outflows," explained by migratory trends. The issue with this type of data is that it is usually confidential; only the centers and the families associated with them can access the results of their students or children, along with the averages for the region. The results are never made public.

Therefore, to answer the first research question on what statistical sources are available for longitudinal analysis of the learning outcomes of a population over time, regarding the available statistical sources that allow us to conduct a longitudinal analysis of the population's learning outcomes over time, based on the sources we have outlined above, it appears that the most suitable sources are the diagnostic tests performed annually by the educational administrations. These tests are based on census data and cover all years, making it straightforward to track changes within a particular age group. However, this data is not publicly accessible, meaning that only the teams responsible for monitoring the academic results of schools can access this information. Not even professionals (teachers or professors) are fully aware of the overall performance of the education system; they only know about the circumstances within their specific institutions. Other learning outcome data come from international surveys (PISA, TIMSS, PIRLS, PIAAC). However, the limitation of these data is that they are sample-based and not conducted annually, which means that there may be gaps for specific age groups. These surveys provide a static

3.2. Types of Information We Can Find in Selected Data Sources (RQ2)

We have seen that there are two types of educational data available, census and sample data. The former are the ones that best fit the purpose of REVERS-ED, which is to analyze and understand the forms of educational inequality through the study of the educational trajectories of three age cohorts. UNESCO and Eurostat data provide us with information on variables such as those shown in Table 9.

The World Bank Group also has an extensive longitudinal education database, with more than 8450 data series covering education data for decades, in 272 countries available. Many of these data also come from the above two sources (as well as from international surveys conducted by the OECD).

Table 9. Education indicators from the two major international education databases.

Databases	Indicators
Eurostat	- Education and training ○ Participation in education and training ▪ Pupils and students' enrolments ▪ Pupils and students entrants ▪ Adult learning ▪ Continuing vocational training in enterprises ○ Learning and mobility ▪ Mobile students from abroad ▪ Degree mobile graduates from abroad ▪ Credit mobile graduates ○ Education personnel ▪ Teachers and academic staff ▪ Distribution of teachers and academic staff ○ Education and finance ▪ Expenditure on education ▪ Expenditure of/on public and private educational institutions ○ Education and training outcomes ▪ Graduates ▪ Educational attainment level ▪ Transition from education to work ○ Languages ▪ Language learning ▪ Self-reported language skills ○ Education-administrative data until 2012 (ISCED1997) ○ Past series
UNESCO	SDG4 Monitoring - Government expenditure on education - Target 1.a ○ Indicator 1.a.2. Expenditure on education - Target 4.1. Basic education ○ Indicator 4.1.0. Preparedness for the future ○ Indicator 4.1.1. Minimum proficiency level in reading and mathematics ○ Indicator 4.1.2. Completion rate (observed data) ○ Indicator 4.1.2. Completion rate (modelled data) ○ Indicator 4.1.3. Gross intake ratio to the last grade ○ Indicator 4.1.4. Out-of-school rate (administrative data) ○ Indicator 4.1.4. Out-of-school rate (household data) ○ Indicator 4.1.4. Out-of-school rate (modelled data) ○ Indicator 4.1.5. Over-age for grade (administrative data) ○ Indicator 4.1.5. Over-age grade (household survey data) ○ Indicator 4.1.6. Learning assessment ○ Indicator 4.1.7. Years of free/compulsory education (primary/secondary) - Target 4.2. Early childhood ○ Indicator 4.2.1. Health, learning, and psychological development ○ Indicator 4.2.2. Adjusted net enrollment rate (administrative data) ○ Adjusted net attendance rate (household survey data) ○ Indicator 4.2.3. Positive and stimulating home learning environments ○ Indicator 4.2.4. net enrollment rate ○ Indicator 4.2.5. Years of free/compulsory education (pre-primary)

Table 9. *Cont.*

Databases	Indicators
UNESCO	- Target 4.3. Technical, vocational, and tertiary education ○ Indicator 4.3.1. participation in education and training ○ Indicator 4.3.2. Gross enrollment ratio ○ Indicator 4.3.2. Gross attendance ratio ○ Indicator 4.3.3. Participation in vocational education - Target 4.4. Skills for employment ○ Indicator 4.4.1. Information and communications technology skills ○ Indicator 4.4.2. Digital literacy skills ○ Indicator 4.4.3. Educational attainment rates - Target 4.5. Equity ○ Indicator 4.5.1. Parity indexes ○ Indicator 4.5.2. Language of instruction ○ Indicator 4.5.3. Education funding for disadvantaged populations ○ Indicator 4.5.4. Education expenditure per student (GDP Per Capita) ○ Indicator 4.5.4. Education expenditure per student (constant PPP$) ○ Indicator 4.5.5. Education aid to the least developed countries ○ Indicator 4.5.6. Expenditure on education as a percentage of GDP - Target 4.6. Youth and adults' literacy and numeracy ○ Indicator 4.6.1. Proficiency in literacy and numeracy skills ○ Indicator 4.6.2. Literacy rate ○ Indicator 4.6.2. Literacy rate (estimate using the Global Age-Specific Literacy Projections Model) - Target 4.7. Education for sustainable development ○ Indicator 4.7.1. Mainstream of global citizenship education ○ Indicator 4.7.2. HIV and sexuality education ○ Indicator 4.7.3. Greening education ○ Indicator 4.7.4. Understanding of global citizenship and sustainability ○ Indicator 4.7.5. Knowledge of environmental science and geoscience - Target 4.a. School environment ○ Indicator 4.a.1. Basic school services/facilities ○ Indicator 4.a.2. Bullying ○ Indicator 4.a.3. Number of attacks - Target 4.b. Scholarships ○ Indicator 4.b.1. Official development assistance (ODA) - Target 4.c. Qualified teachers ○ Indicator 4.c.1. Teachers with minimum qualification ○ Indicator 4.c.2. Pupils to trained teacher ratio ○ Indicator 4.c.3. Qualified teachers ○ Indicator 4.c.4. Pupils to qualified teacher ratio ○ Indicator 4.c.5. Teacher salary ○ Indicator 4.c.6. Teacher attrition rate ○ Indicator 4.c.7. In-service teacher training

Thus, to answer the second research question, the data provided by available statistical sources on education is fundamentally descriptive. With this type of data, it is possible to create explanatory models that seek correlations between variables. Statistical tools also enable us to apply techniques such as the least squares line and use statistical tests to measure how well the data fits the regression line. This helps us control uncertainty and offer interpretations with certain margins of reliability. However, we recognize that these models operate under the assumption of causality, which never becomes a certainty beyond the

margins defined by a specific probability (and assuming the "normality" of the distribution or its alignment with any other behavior of the data—logarithmic, exponential, etc.). In any case, inputs from these sources allow us to generate more or less detailed descriptions of the state of education in a given country, as well as to examine the relationships among educational outcomes (such as the number of graduates per level, distributed by gender, school ownership, graduates in STEM programs, educational attainment—controlled by gender, age, country of birth, etc.), citizenship, employment status by education level, and educational attainment—controlled by gender, age, country of birth, citizenship, employment status by level of studies, the distribution of male and female graduates in different fields of education, and many other aspects—with factors such as the socioeconomic status of families, whether or not students are migrants, the funding received by schools, the quality of teacher training, the student-teacher ratio, etc.

3.3. Scope of Available Source Data in Education (RQ3)

Usually, the aspects discussed in the previous section have been used to justify the educational policies and programs carried out by countries. The data allow us to analyze the incidence of legislative measures on the results achieved by following age cohorts that have undergone legislative changes that have changed the focus, investment of resources, and curriculum in education. For example, we can observe that countries where ability-level education pathways are banned (e.g., Finland) and countries that emphasize free education and focus on instrumental subjects throughout the education system, such as Ireland, tend to perform better in math, science, and reading in surveys such as PISA, than countries where young people are separated into different educational pathways (scientific, or scientific-technical, versus humanities), as is the case, for example, in Sweden (where the friskolor policy that has privatized education in that country has resulted in a very significant decline in the performance of Swedish students in mathematics, reading and science, according to data from the latest PISA reports).

However, these data provide us with "broad outline" information, i.e., the impact on learning outcomes of, on the one hand, political decisions on issues such as "free education", "educational pathways" oriented towards university or vocational training, ability grouping, and on the other, sociodemographic variables that describe situations of vulnerability and non-vulnerability (socioeconomic status, investment in education, percentage of expenditure per student and Per Capita, measured by weight in GDP, etc.).

These indicators are important for those responsible for deciding on educational policies, but are they also relevant for those who must determine what actions to implement in the classroom? What is the impact of using the Singapore method or the realistic mathematics approach in teaching mathematical problem-solving? What is better for improving learning: grouping students in interactive groups or organizing learning corners that are free for student choice? Is the discovery approach, the word method, or inquiry-based learning better? Is constructivist meaningful learning superior to the teach-and-drill method? What if we use classic readings in the classroom or substitute them with adaptations to children's tastes, "to encourage and motivate reading"? Teachers must make decisions every day to translate curriculum guidelines into learning situations that allow their students to learn. Research is gradually compiling successful educational actions (Flecha 2014) that enhance learning. However, while we are aware of many practices, methodologies, and some successful educational actions, as demonstrated, the statistical data typically available tend to be primarily descriptive in nature—for example, enrollment rates, dropout rates, and attainment levels across various subjects. There is, however, a notable scarcity of statistical data specifically focused on evaluating the effects of implemented educational interventions on student learning outcomes. Some resources are available (Education

Endowment Foundation 2025), and more studies are being published in this direction (Flecha et al. 2025). This limitation poses a significant challenge for identifying which actions are most effective, thus constraining the evidence base needed to inform decisions regarding their potential adoption in educational practice. Moreover, there are no databases that collect the results of implementing these actions on students' learning and academic performance. Some educational administrations are aware of the measures and approaches that schools apply and track their results through diagnostic tests. They know what schools do and what performance their students achieve on standardized tests. However, those results are never made public, not even in an anonymized database that could track the outcomes of various performance levels.

This reality greatly limits (a) the scientific knowledge we have about how learning, education, and the impact that different actions have on that learning, and (b) forces educational decision-makers to make decisions intuitively, with partial (and who knows if biased) information. Teachers do not know what will happen if they decide to group their students homogeneously or heterogeneously (to concentrate and optimize the use of resources, for example, or to generate reinforcement programs, etc.), because they do not have a database they can access to know what the percentages of learning improvement/improvement are according to the option they decide on. These decisions are either based on beliefs, or on previous training (supposedly based on scientific knowledge from specialized studies), or on the use of and access to scientific evidence on educational actions, or decisions of an ideological nature, or simply because it is "the way I was taught." Decision-makers at the level of the educational system find themselves in similar situations. From the research point of view, it also happens that we have limitations to generalize the findings that come from case studies to see whether or not they are replicable to the whole population, which slows down and makes it very difficult to improve our knowledge of learning to find more effective ways that can be applied to improve the limits of our knowledge.

4. Discussion

In recent decades, most countries around the world have established institutions dedicated to collecting data on the functioning of their education systems. International organizations such as UNESCO, the OECD, the World Bank, and Eurostat, among others, have invested considerable resources in monitoring and assessing the global state of education. At the same time, there is growing public demand for access to reliable information in pursuit of the shared objective of raising educational attainment levels worldwide. The Sustainable Development Goals (SDGs) exemplify this global civic agenda, reflecting the aspirations of countless individuals across multiple spheres of life.

Despite these efforts, there remains a notable absence of studies examining whether the data produced by international organizations, national bodies, research agencies, and other entities effectively contribute to achieving the SDGs or to addressing persistent educational inequalities.

Concerns regarding educational assessment are not new. International research networks such as the European Conference on Educational Research (ECER), the American Educational Research Association (AERA), and the World Educational Research Association (WERA)—three of the leading organizations in the field—have long dedicated attention to this area. Annual international conferences regularly feature specialized research groups focusing on educational assessment. Previous research has shown that a wide range of variables influence academic performance and learning outcomes (Hattie and Anderman 2013).

Nevertheless, when seeking statistical data on the impact of specific educational interventions—akin to how a medical professional might require evidence of the efficacy

of a treatment for a particular condition—significant challenges emerge. In this article, we have sought to address this gap by compiling a broad sample of relevant data sources and analyzing the type of information they provide concerning educational processes and outcomes.

After analyzing the statistical data sources described in this article, we can conclude the following:

(1) We have national and international statistical data sources that provide information on various aspects related to education and learning, investment in education, the school system, teachers, education levels, educational attainment, graduates, and more, controlled by numerous specific variables (such as sex, mothers' level of education, school ownership, Internet access, and the number of books in the home). The data consist of either census or sample data. Census data is typically longitudinal (year to year), while sample data are collected periodically; however, as they are samples, they do not strictly meet longitudinal criteria. PISA, TIMSS, PIRLS, and PIAAC are longitudinal from the perspective of the country, not from the perspective of the cohorts participating in the study.

(2) These data allow us to understand significant trends in education and specific aspects that we can infer through the development of models, utilizing statistical techniques, while always assuming certain margins of reliability. Predictive models in education are rare and can be significantly affected by uncontrolled variables whose effects are unknown. The level of prediction is limited in scope and timeframe.

(3) In light of the analysis of available statistical data sources, we must state that while it would be possible to identify which educational actions improve education, the current instruments and databases do not allow for this. There is still no universal database (or by countries, regions, etc.) that is anonymized and complies with strict ethical standards of personal data protection, while also providing disaggregated data to measure the impact of each educational action known to us (and those that will be found in the future) on education and learning.

5. Conclusions

In this article, we have aimed to contribute to the academic discourse surrounding the adequacy of existing educational data for informing decision-making, both at the classroom level and within the broader education system. Specifically, we have examined whether current data sources provide sufficiently detailed evidence of the effects of implementing specific educational actions. Similar developments can be observed in other areas of the social sciences, where there is a growing emphasis on generating scientific evidence of social impact (Flecha 2017; Flecha Garcia et al. 2022). Reliable information is essential to guard against decisions based on misinformation or unfounded assumptions, and to prevent the adoption of educational practices that, rather than enhancing learning and reducing inequalities, risk reinforcing them.

Our research suggests that the possibility of devising and organizing more advanced longitudinal educational research and educational policy evaluation at a comparable international level should be explored.

Currently available official national and international education statistics are useful basic instruments to assess situations and trends in educational achievements. However, to study the effects of educational practices and policies, two types of scientific research are needed to complement those basic statistics: (1) Specific longitudinal investigations in which more thorough variables about students cognitive and personality abilities, motivations, and performances, school and teacher attitudes and practices, and family and neighborhood are recorded, analyzed and publicized. (2) Educational policy research

should be linked to available educational data sources. However, what is often missing is the combination of both types of research, either because the conceptual framework is missing, or the financial means do not allow a sufficiently prolonged analysis of research data after the completion of the data gathering. Aware that much educational policy making is a national prerogative, nevertheless, efforts should be made to examine the possibility of devising and organizing more advanced longitudinal educational research and educational policy evaluation at a comparable international level.

In the future, it is conceivable that databases will be developed to systematically capture the outcomes of all implemented educational actions, anonymising students' personal data while enabling researchers to analyze the impact of these interventions. From a technical standpoint, the creation of large-scale databases capable of collecting such data at the school level is already feasible. Indeed, many countries already possess institutional bodies for educational evaluation that systematically gather student performance data and are aware of the curricular frameworks and specific actions implemented in each school. Access to such data could substantially enhance the social utility of educational research.

However, as long as we are unable to ensure the full anonymisation of these data—thus preventing ethical breaches and safeguarding against social, cultural, religious, or other forms of bias—and as long as administrative barriers to data sharing and public access persist, research of this nature will remain confined to the case study level (Flecha et al. 2025).

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Appendix A. Initial Selection of Data Based on SDG 4

Source	MET = Ministry of Education and Training; FWB = Federa-tion of French-Wallonia	NSI = National Statistical Institute; ITU = International Telecommuni-cation Union	MCE = Ministry of Children and Education; SD = Statistics Denmark; ICILS = International Computer and Information Literacy Study; PIAAC = Programme for the International Assessment of Adult Competencies; ICCS = International Civic and Citizenship Education Study	UNESCO HDX = Humanitarian Data Exchange; HSA = Hellenic Statistical Agency; ICCS = International Civic and Citizenship Education Study	GUI = Growing up in Ireland; CSO = Central Statistics Office; HBSC = University of Galway; ECCE = Early Childhood Care and Education scheme; HEA = Higher Education Authority; QNHS = Quarterly National Household Survey; NCCA = National Council for Curriculum and Assessment; DES = Department of Education and Skills; ERC = Educational Research Centre.	ISTAT = Italian National Institute of Statistics; INVALSI = National Institute for the Evaluation of the Education System; MIUR = Italian Ministry of Education, University, and Research; StCI = Save the Children Italy; AAI = ActionAid Italy	NEA = National Education Agency; EMIS = Education Management Information system; SVIS (Valdymo Informacine Sistema); OSP = Lithuanian Official Statistics Portal; EC= European Commission; ETM-EC = Education and Training Monitor by European Commission; EASIE = European Agency Statistics on Inclusive Education; OECD-EaG = OECD Education at a Glance; TALIS = Teaching and Learning International Survey -OECD-; ICILS = International Computer and Information Literacy Study by IEA; GEM-UNESCO = Global Education Monitoring Report; E4A-UNESCO (Education for All); UIS Sustainable Dev. Goals; WIDE = World Inequality Database on Education	DGEEC = Directorate General of Education and Science Statistics; IAVE = Instituto de Avaliaçao Educativas	"FNAE = Finnish National Agency for Education; SF = Statistics Finland; FIHW = Finnish Institute for Health and Welfare; PIAAC = Programme for the International Assessment of Adult Competencies; ICILS = International Computer and Information Literacy Study; ICCS = International Civic and Citizenship Education Study; MECF = Ministry of Education and Culture Finland Study)"

Country	BE (PSPC)	BG (Institut of Education)	DK (AU)	GR (KMOP)	ES (UB)	IE (DCU)	IT (UNISI)	LT (PPMI)	PT (DGEEC)	RO	FI (JUY)
SDG 4								2013–23—SDG4-UNESCO//UIS UNESCO (2017–23)//ES WORLD BANK (2005–2018)// WIDE			
Target 4.1. By 2030, ensure that all girls and boys complete free, equitable, and quality primary and secondary education leading to relevant and effective learning outcomes					x						
Indicator 4.1.1. Proportion of children and young people (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex			2010–2023 (MCE)		x	x	2015–2023 (INVALSI) 2000–2023 (PISA)	2009–23 (NEA; EMIS; SVIS)			
Indicator 4.1.1.: (sub-indicator) These are data on national exams (Valstybiniai brandos egzaminai—State Maturity Exams) taken by students at the end of their secondary education, typically in the 12th grade. The results are available for Lithuanian language and literature, and mathematics, among many other subjects.								2006–24 (NEA)			

Indicator 4.1.1. Suindicator: This test is taken by 10th-grade students to assess their academic performance, typically in subjects like Lithuanian language and literature and mathematics, at the end of their basic education level.	2013–24 (NEA)
Indicator 4.1.1. Suindicator: Provides data on regular and non-formal education, student enrollment, foreign student participation, Olympiad winners, and public service statistics.	2019–24 (OSP)
Indicator 4.1.1. Subindicator: Provides comprehensive education-related statistics, including data on formal and non-formal education, educational establishments from preschool to higher education, and culture.	2012–22 (OSP)
Indicator 4.1.1. Sub-indicator: Provides data (comparative reports) on numerous indicators, such as early school leaving, regular, non-formal learning, and higher education.	2024 (EC—Eurydice)

Indicator 4.1.1. Sub-indicator: Provides detailed analysis and data on Lithuania's education system, focusing on indicators such as early school leaving, student performance, participation in secondary and vocational education, teacher shortages, and socio-economic disparities in education.		2020–23 (ETM-EC)
Indicator 4.1.1. Sub-indicator: Provides comprehensive education and training statistics, including data on participation in formal education, vocational training, adult learning, learning mobility, education personnel, and education finance.		2024 (Eurostat)
Indicator 4.1.1. Focuses on educational attainment, teachers, school performance, and public expenditure. Key aspects include the structure of Lithuania's education system, vocational education, and academic performance comparisons with OECD averages.		2023 (OECD, EaG)

Indicator 4.1.1. Provides data on teachers' working conditions and learning environments in over 30 countries. It surveys a representative sample of lower secondary teachers and school leaders. It provides data on teacher-student ratios and engagement levels, key for educational inequality analysis.		2008–18 (TALIS)
Indicator 4.1.1. Provides insights into students' ability to use computers to investigate, create, and communicate effectively. It assesses how well students are prepared for life in a digital world. The study also includes contextual data on students' home and school environments, teacher readiness, and digital resources. Additionally, it offers an optional assessment of computational thinking, covering programming and data structuring skills.		2013–23 ICILS
Indicator 4.1.1. Provides detailed analyses of education systems globally, with a focus on technology access, usage, and its impact on learning outcomes.		2002–23 (GEM-UNESCO)

Indicator 4.1.1. Provides comprehensive data on Lithuania's progress towards the six Education for All goals, focusing on early childhood education, primary education, adult literacy, gender parity, and quality of education. It includes data on enrollment rates, access to education, educational outcomes, and funding, as well as information on national policies and strategies for improving education.						2000–2015 (E4A, UNESCO)		
Sub-indicator 4.1.1.1.1. Reading literacy of 4th-grade students and performance of 4th and 8th-grade students in mathematics and science.		2018–2024 (Institute of Education)					2011, 2016 (PIRLS), 2015–2019 (TIMSS)	
Sub-indicator 4.1.1.1.1. Proportion of young people who, at the end of lower secondary education, have achieved at least a minimum level of proficiency in reading (PISA)	2000–2022 (PISA)	2009–2022 (PISA)	2000–2022 (PISA)	2000–2022 (PISA)	2019–22 (2022) PISA	2000–22 (PISA)		2009–2022 (PISA)
Sub-indicator 4.1.1.2. Proportion of young people who, at the end of lower secondary education, have achieved at least a minimum level of proficiency in mathematics (PISA)	2000–2022 (PISA)	2012–2022 (PISA)	2000–2022 (PISA)	2000–2022 (PISA)	2019–22 (2023) PISA			2009–2022 (PISA)

Sub-indicator 4.1.1.3. Proportion of young people who, at the end of primary school education, have achieved at least a minimum level of proficiency in reading (PIRLS/GUI/TIMSS NAMER)	2006–2021 (PIRLS)	2001–2021 (PIRLS)	2006–2021 (PIRLS)	2001-? (PIRLS)		2011–22 (PIRLS); 2008–23 (GUI); 2009–21 (T.NAMER).		1995–2019 (TIMMS)	2011–2021 (PIRLS)
Proportion of young people who, at the end of primary school education, have achieved at least a minimum level of proficiency in mathematics (TIMSS, NAMER, GUI).	1995–2023 (TIMSS)	2015–2023 (TIMSS)	2007–2019 (TIMSS)			1995–2019 (TIMSS); 2008–2023 (GUI); 2009–2021 (NAMER) (Last 2019)		2001–2021 TIMSS	2011–2023 (TIMSS)
Indicator 4.1.2. Completion rate (primary education, lower secondary education, upper secondary education)	2011–2021 (MET)			2006–2022 (UNESCO); 2000–2021 (HSA)	x	2008–24; 1991–2022 (Census)	2010–2022 (ISTAT); 2019–2023 (MIUR)		2000–2024 (FNAE) 2000–2017 (SF)
Sub-indicator 4.1.2 The percentage ratio between the number of students who, at the end of a school year, pass (being able to move on to the next school year) and the number of students enrolled in that school year. We use the term “completion rate” when referring to achievement in the final year of a level of education, i.e., 9th and 12th grade. Notes: This indicator refers to general basic education, scientific-humanistic courses, courses with their own plans, and vocational courses. The term “completion rate” refers to the successful completion of basic or secondary education (9th or 12th grade, respectively).		2019–2024 (NSI)	2007–2024 (MCE)	1990–2024 (UNESCO HDX)					1999/ 2000–2022–23 (DGEEC)

Sub-indicator 4.1.3.1 Rate of students completing on the expected time all educational levels (1) primary education: first cycle in four years, second cycle in two years, (2) lower secondary education: third cycle, and (3) upper secondary education in three years. This indicator disaggregation is by regional level, School, and School Clusters.	2013–2021 (FWB)	2018–2023 (NSI)	2015–2022 (Eurostat)		2017–18/ 2021–22 (DGEEC)
Sub-indicator 4.1.4.1 Rate of students with school social support (ASE), completing on the expected time all the educations levels (1) primary education: first cycle in four years, second cycle in two years, (2) lower secondary education: third cycle and (3) upper secondary education in three years. This indicator is disaggregated by regional level and School Clusters.					2017–18/ 2021–22 (DGEEC)
Sub-indicator 4.1.5.1 Equity indicator for regional level, School Clusters, and by education level—primary education (first and second cycle), lower secondary education (third cycle), and upper secondary education (general and vocational)				2015–2023 (StCI)	2017–18/ 2021–22 (DGEEC)

Other indicator/s (specify)			Qualitative evaluations from teachers determine if students are considered "ready" for various upper secondary tracks. 2011–2024 (MCE)		x				
Target 4.2. By 2030, ensure that all girls and boys have access to quality early childhood development, care, and pre-primary education so that they are ready for primary education.					x				
Indicator 4.2.1. Proportion of children aged 24–59 months who are developmentally on track in health, learning, and psychosocial well-being, by sex					x	2011 (GUI); 2022 (CSO); 1998–2022 (HBSC)			2017–18/2020/ 2024 (FIHW)
Indicator 4.2.2. Participation rate in organized learning (one year before the official primary entry age), by sex	2013–2022 (MET)	2019–2024 (NSI)		2013–2022 (Eurostat)	x	2021–23 (ECCE)	2010–2023 (StCI); 2010–2023 (ISTAT)		2015–2023 (SF)
Sub-indicator 4.2.2.1 Number of children with 5 and 6 years old enrolled in pre-school by sex								1999–2000/ 2022–23 (DGEEC)	
Sub-indicator 4.2.3.1 Real pre-school enrollment rate			2013–2022 (Eurostat)					2003–4/ 2022–23 (DGEEC)	
Sub-indicator 4.2.4.1 Gross enrollment rate in pre-school education								2003–4/ 2022–23 (DGEEC)	
Other indicator/s (specify)					x				

Target 4.3. By 2030, ensure equal access for all women and men to affordable and quality technical, vocational, and tertiary education, including university education				x			
Indicator 4.3.1. Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex	2007/2011/2016/2022 (NSI)	1990–2022 (SD)	1992–2023 (Eurostat)		2021–22 (HEA); 2017–2022 (CSO)		1999–2022 (SF) (FNAE)
Indicator: Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex				x		2003/2004–2022/23 (municipalities in Autonomous Regions since 2009/2010) (DGEEC)	
Indicator 4.3.2.1. Transition rate (after one year) between secondary education and higher education.						2010–11/2021–22 (DGEEC)	
Sub-indicator 4.3.4.1. Percentage of students continuing their studies in higher education one year after completing a short-cycle tertiary education course (CTeSP) by sex, age, region (NUTS II and district), higher education subsystem, and institution.						2015–16/2021–22 (DGEEC)	
Sub-indicator 4.3.5.1. Percentage of students who have completed a Bachelor's or equivalent courses by sex, age, region (NUTS II and district), higher education subsystem and institution, and field of study.			2006–2022 (UNESCO)			2013–14/2021–22 (DGEEC)	

Sub-indicator 4.3.6.1 Percentage of students continuing their studies in higher education one year after completing a bachelor's or equivalent course by sex, age, region (NUTS II and district), higher education subsystem and institution, and field of study.						2015–16/ 2021–22 (DGEEC)	
Other indicator/s (specify)				x			
Target 4.4. By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship				x			
Indicator 4.4.1. Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill	2018–2022 (ITU)			x	2017–24 (QNHS)		2012/2023 (PIAAC)
Sub-indicator 4.4.1.1. Digital and information literacy of young people in the 8th grade.		2013–2023 (ICILS)	2022 (ICILS)			2018 (IAVE)	2018/2023 (ICILS)
Other indicator/s (specify)				x			
Target 4.5. By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples, and children in vulnerable situations.				x			

Indicator 4.5.1. Parity indices (female/male, rural/urban, bottom/top wealth quintile, and others such as disability status, indigenous peoples, and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated	1990–2022 (SD)		x	2012–19 (CSO)	2010–2023 (StCI)			2008–2024 (SF)
Indicator 4.5.1. Provides detailed statistics on the inclusion of learners with special educational needs (SEN) in mainstream education, special education settings, teacher support, and student outcomes. It includes data on the number of children/learners in the education system, SEN identification rates, inclusion rates, and public expenditure on inclusive education.						2012–22 (EASIE)		
Other indicator/s (specify)			x					
Target 4.6. By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.			x					
Indicator 4.6.1. Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex	2012/2022 (PIAAC)	2015 (PIAAC)	x	2016–2019 (CSO)	2011–2023 (PIAAC)			2012/2023 (PIAAC)

Sub-indicator 4.6.1.1. Percentage of students with 15 years old by math and reading proficiency level (PISA)						"Reading—2000, 2009, and 2018 Mathematics—2003, 2012, and 2022 Science—2006, 2015, and 2025 (IAVE)"	
Other indicator/s (specify)			x				
Target 4.7. By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development			x				
Indicator 4.7.1. Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education, and (d) student assessment	2009–2022 (ICCS)	2009–? (ICCS)	x	2016–22 (NCCA)	2015–2023 (AAI)		2016 (ICCS)
Sub-indicator 4.7.1.1 Number of students of 2nd and 3rd cycles attending citizenship classes						2023/22 (DGEEC)	

Target 4.a. Build and upgrade education facilities that are child, disability, and gender sensitive and provide safe, non-violent, inclusive, and effective learning environments for all	x		
Indicator 4.a.1. Proportion of schools offering basic services, by type of service	x	2017–24 (DES, ERC)	2000–2023 (SF) 2020–2022 (MECF)

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