International Journal of Educational Research Open 8 (2025) 100445

Contents lists available at ScienceDirect

International Journal of Educational Research Open

journal homepage: www.elsevier.com/locate/ijedro

A long road to educational equity: Tracking trends through PISA 2000–2018

Ekaterina Enchikova [a], Tiago Neves [a], Cibelle Toledo [a], Gil Nata [a,b,*]

[a] Centre for Research and Intervention in Education, University of Porto, Porto, Portugal
[b] University of Trás-os-Montes e Alto Douro, Vila Real, Portugal

ARTICLE INFO

Keywords:
Educational equity
Equality of opportunity
R-Squared
ESCS
PISA
Change in equity

THE AUTHORS INFORMATION IS BLINDED

The OECD's Programme for International Student Assessment (PISA) has reported on the levels of educational equity in participating countries since its inception in 2000. However, little attention has been paid to changes in equity levels over time. This study analyses data from the 2000 to 2018 PISA rounds, offering an overview of educational socioeconomic-related equity — specifically equality of opportunity (assessed through the relationship between R-squared and ESCS) — trends across 87 countries, comprising 37 OECD members and 50 partner countries. It provides insights into the dynamics of equity levels at the country level, the stability of these trends, and the consistency of the changes. By using all available PISA waves for each participating country, calculating an average R-squared between subjects (Reading, Math and Science), and combining the "absolute" position in the equity indicator with the change over time in that same indicator, this study presents the first comprehensive picture of the evolution of equality of opportunities (assessed through the R-squared indicator) in all PISA-participating countries. Results show that, on average, PISA-participating countries have only slightly improved their equality of opportunity. Additionally, there is an absence of clear patterns regarding the relationship between equity levels and equity change, highlighting the diversity of national pathways to equity and underscoring the importance of analysing specific contexts when assessing equity. Lastly, this study also helps to identify successful country cases that have demonstrated more solid and coherent positive trends in improving educational equity over the last two decades.

1. Introduction

Ever since educational systems made education widely available, there has been a problem with the unequal distribution of this resource. Who can access it, and who cannot? Education has often been a privilege of those in power. Women, minorities, and members of lower socio-economic status groups were often denied access to education, perpetuating cycles of disadvantage. The social and political debate around the distribution of educational resources led to the concept of educational equity, which is deeply connected with the concepts of human rights and equality (Bulkley, 2013; Unterhalter, 2009). At its most fundamental, equity means that all students, regardless of their economic, social, and cultural status, race, gender, ethnicity, language, disability, sexual orientation, or other personal or social circumstances, have equal access to educational opportunities and resources (OECD, 2017a). Over the 20th century, the struggle for educational equity led to significant social and political changes, including movements for women's rights, civil rights, and universal public education (Ainscow, 2020; Espinoza, 2007). The importance of educational equity is stated in policy texts worldwide, including, Article 26 of the Universal Declaration of Human Rights (United Nations, 1948), the International Covenant on Economic, Social and Cultural Rights (United Nations, 1966), the Convention against Discrimination in Education (United Nations, 1962), the Convention on the Rights of the Child (United Nations, 1989), and the UN General Assembly Resolution on the Right to Education in Emergency Situations. The latter binds nations worldwide to respect, protect and fulfil every child's right to education (UNESCO, 2017). In this study, we focus specifically on socioeconomic equity in education.

The Organization for Economic Co-operation and Development (OECD) supports the United Nations (UN) and its agencies in implementing Sustainable Development Goals (SDGs). However, a recent report shows disappointing results in achieving them (United Nations, 2023). The latest reports from the OECD's Programme for International Student Assessment (PISA) also show that equity-related goals remain

* Corresponding author.
E-mail addresses: ekaterina@fpce.up.pt (E. Enchikova), tiago@fpce.up.pt (T. Neves), ctoledo@fpce.up.pt (C. Toledo), gilnata@utad.pt (G. Nata).

https://doi.org/10.1016/j.ijedro.2025.100445
Received 1 December 2024; Received in revised form 20 January 2025; Accepted 21 January 2025
Available online 5 February 2025

unfulfilled. In the 2022 PISA report, children's economic, social, and cultural status (ESCS) explained 12%−16% of the variance in reading, science, and mathematics, on average, in the OECD countries. In some countries, these values were higher than 20% (Belgium, France, Hungary, Peru, and Argentina) (OECD, 2019). The 2022 report declares that out of the 68 countries with available data, the ESCS gap in mathematics widened in 12 countries, narrowed in 5 countries, and did not change in 51 countries between 2018 and 2022 (OECD, 2023). Despite all efforts, the students' social and economic backgrounds are still strongly connected with school performance.

In comparison to other international large scale assessments, PISA has been the assessment that has paid greater attention to equity and its change over time. In fact, equity has consistently been highlighted in the main PISA reports. Entire volumes have been specifically dedicated to the study of equity. Searching academic databases regarding equity in education results in almost 4 times more publications that refer to PISA compared to other international large-scale assessments. This suggests that PISA is the most authoritative large-scale comparative data source when it comes to studying equity change.

While PISA systematically reports on the educational equity levels in participating countries and plays a role in shaping educational policies, the format and presentation of these data fall short of providing a clear picture of the participating countries' progress toward achieving more equitable education. Most reports focus on the current situation within each country and provide very limited information regarding the change in equity over time. This research aims to address this gap by collecting the data from every round of PISA and elaborating on the trends in equity for each participating country. This offers a more detailed picture of the progress made in each country, identifying the countries with positive and negative trends and enabling a better understanding of the shifts over nearly two decades.

2. PISA, (socioeconomic-related) equity and its assessment

Since its beginning in 2000, PISA has declared the promotion of educational equity amongst its core values and goals. Since then, every three years, there has been a round of PISA, collecting data and reporting on the current situation in educational equity, with a total of seven rounds of PISA. Every year, PISA has provided recommendations regarding promoting equity in the participating countries (OECD 2004, 2017b, 2019; Schleicher, 2009).

Equity is a complex, polysemic, and therefore difficult concept to define and gauge. As this is not a main focus of the present work, we refer the readers interested in the nuts and bolts of the concept and its measurement to the works of Appels et al. (2023), UNESCO's handbook on measuring equity in education (2018), Espinoza (2007) and Enchikova, Neves, Toledo and Nata (2024). This latter work consists of a systematic review of the literature addressing the change in equity after 20 years of PISA. In it, a framework for the classification of the different equity indicators found in the reviewed literature is presented, entailing four main categories: (i) equality of outcome, which refers to differences in educational results, regardless of their determinants, entailing indicators such as the dispersion (variance or standard deviation) of educational results or the difference between the 90th and 10th (or other) percentiles in a given outcome (e.g., the reading results in PISA); (ii) equality of opportunity, which refers to the association between background characteristics (such as the educational level of parents, their wealth, or cultural status) and educational results, encompassing indicators such as the proportion of variance (commonly referred to as R-squared) of a given outcome (such as a result on a PISA test) explained by the socioeconomic background of the parents, or the strength of this relationship (in more technical terms, the degree of increase in a given outcome by each unit of increase in the background variable, also referred to as the slope of the relation); (iii) resilience, which refers to the possibility of overcoming socioeconomic adversity, usually assessed by indicators that gauge the proportion of disadvantaged students (e.g., from the lower socioeconomic quartile) that are able to perform significantly high (e.g., the higher quartile of certain subject, such as Math); and (iv) segregation, which refers to the non-random distribution of students across a geographical unit of analysis (usually schools) according to an educational outcome (such as academic results) or background variables (such as the socioeconomic level of students' parents).

It is important to notice that different authors and institutions do not use equity-related terms consistently or in the same way. For example, UNESCO's handbook on equity measurement (2018) prefers the term *impartiality* to the — as they themselves acknowledge — more dominant concept of equality of opportunity, for reasons that are beyond the scope of the present work. Others, in direct accordance with what the indicators actually assess, prefer to use terms in their "negative" formulation, such as achievement *inequality* (e.g., Ali, Ow-Yeong & Tilley, 2024), educational *inequity* (rather than equity) (e.g., Holgado-Aguadero, Martínez-Abad & Hernández-Ramos, 2024; Martínez-Abad et al., 2024) or *inequality* of opportunities (e.g., Marrero, Palomino & Sicilia, 2024). In the current study, as stated above, we are deferring to the framework presented by Enchikova et al. (2024) and focusing on one specific indicator of equality of opportunities, arguably the most famous one: R-squared. Given that the current study uses indicators retrieved from PISA official reports, it is also relevant to provide an overview of how PISA itself has conceptualized equity and its measurement.

Generally, "PISA defines equity in education as providing all students, regardless of gender, family background or socioeconomic status, with similar opportunities to benefit from education" (OECD, 2013, p. 27). Beyond this general definition, PISA reports have produced diverse indicators and changed the focus of their analysis across the different waves.

In 2000, equity was mainly discussed from the perspective of educational quality and defined by the between-school variance of students' performance (OECD 2003). Socioeconomic status was discussed from the perspective of its impact on performance.

This approach changed in 2003 when the socioeconomic gradient was introduced as a measure of equity (OECD 2004). The socioeconomic gradient indicates the strength of the connection between students' economic, social, and cultural status (ESCS) and their educational outcomes.

In 2006, the socioeconomic gradient was further developed and divided into several indicators: (1) the strength of inequity operationalised as the proportion of observed variation of scores that can be explained by the ESCS index (or R-square coefficient); (2) the extent of inequity operationalised as the change in expected students' scores per one unit of PISA ESCS index (or the slope of the gradient line); (3) the average score obtained by those students in each country that have an ESCS equal to the average across OECD countries, or the intercept; and (4) the length of the gradient lines, defined by the range of ESCS scores for the middle 90% of students in each country, which shows how widely the student population is dispersed in terms of socioeconomic background. (OECD, 2007).

The 2009 PISA report included a separate volume on equity in education, digging deeper into conceptual and methodological issues (OECD, 2010). The report offered three perspectives on educational equity: (1) equity in learning outcomes, measured as relative performance gaps within countries and the share of students at different levels of proficiency (equality of results); (2) equity in the distribution of educational resources (equality of resources); and (3) equity as a relation between students' scores and their background characteristics, such as ESCS, family structure and geographical areas (equality of opportunity).

In the 2012 reports, only two features (of the socioeconomic gradient) remained: the strength (percentage of explained variance) and the slope (score-point difference associated with a one-unit increase in the ESCS index).

In 2015, equity was defined via two related areas: inclusion and fairness (OECD, 2016). Inclusion refers to equal access to educational

resources, measured by PISA coverage[1] and the percentage of students below the 2nd proficiency level.[2] Fairness refers to the connection between socioeconomic background and educational results. It is measured by the socioeconomic gradient's strength and slope, percentage of resilient students, and percentage of between-school variance explained by students' and schools' ESCS.

In 2018, the socioeconomic gradient is again discussed in terms of its' strength and slope (OECD, 2019). However, other indicators were developed and applied, such as mean performance scores by quarters or deciles of the population ranked by ESCS and heterogeneity of ESCS within countries.

3. Using PISA to assess trends in equity over time

The short review above highlights how the concepts, methodology, measurements, and reporting on educational equity have changed across PISA's lifetime. Indeed, not only are there different indicators to measure equity levels, but the exact composition of these indicators may vary. Moreover, each round of PISA has a different focus, featuring one of the subjects (mathematics, reading, or science) as the leading theme and rotating them every 9 years. Thus, there is a 9-year gap between the PISA rounds featuring the same subjects. Probably due to these limitations, PISA reports offer very limited insight into the changes in equity from one round to another. They present comparisons between the years focused on the same subject, comparing only two data points with a 9-year interval between them. On the one hand, this strategy helps maintain higher methodological integrity, but on the other hand, it causes bigger gaps in observations and does not take advantage of the data's full potential. Also, tracking the changes based on two points of observation prevents drawing conclusions regarding the stability and consistency of these changes.

There is a discussion regarding the comparability of the indicators (Davidov, Meuleman, Cieciuch, Schmidt & Billiet, 2014). PISA makes a significant effort to ensure data comparability between waves (Van de Vijver et al., 2019). However, criticism regarding the comparability of the ESCS index remains (Pokropek, Borgonovi & McCormick, 2017; Rutkowski & Rutkowski, 2013), sometimes coming from authors who worked on the development of PISA indexes in the first place (Avvisati, 2020). Nonetheless, there are studies where comparisons are made between different rounds of PISA: while some of them do address the problems of data comparability (Agasisti, Avvisati, Borgonovi & Longobardi, 2021; Anderson, Pittau & Zelli, 2020; Pokropek & Borgonovi, 2020), others pay less attention to these questions (Gromada, Rees & Chzhen, 2019; Le Donne, 2014; Sulis, Giambona, & Porcu, 2020). In some cases, the comparisons are made between 2 rounds of PISA (Anderson, Fruehauf, Pittau & Zelli, 2015, 2020; Gromada et al., 2019; Krüger, 2014; Oppedisano & Turati, 2012), while in other cases more rounds of PISA are included in the analysis (Krüger, 2019; Le Donne, 2014; Lenkeit, Schwippert & Knigge, 2017; Luongo, 2015; Sulis et al., 2020).

The recent literature review by Enchikova et al. (2024) makes a comprehensive mapping of the existing studies that address equity change based on PISA data. Concretely, the study reviews all the available literature that, based on PISA data, has explored changes in any equity indicator across two or more waves, making it possible to draw several important conclusions. One such conclusion is that not all dimensions of equity are equally studied across the literature (including PISA reports), with equality of opportunity being the most studied. Another is that, across equity dimensions, results are largely inconsistent to render any solid conclusion, a situation the authors attribute to several competing factors: ambiguity in the definition of equity itself; different methodological approaches; surprisingly loose (if any) cut-off criteria regarding the definition of what authors interpret as a positive or negative trend; the use of different time-frames/waves. This also holds true in the specific case of equality of opportunity. To put it bluntly, despite the abundant literature addressing the issue, it is not clear whether PISA participating countries were able to improve their equality of opportunity levels in the last two decades. Lastly, another important aspect emerges from the review: the need for studies that combine the evolution of the indicators of any given equity dimension with the "absolute" level of equity in that same indicator.

In this study, we aggregate the data from different PISA rounds to monitor changes in equity. For these comparisons, we focus on one indicator that is available for every round of PISA: the share of variance in PISA scores that can be explained by the students' Economic, Social, and Cultural Status, also known as R-squared (R2). It is important to notice that, for each and every country, we use the equity values published in the PISA reports, the same values that policymakers and stakeholders use in their decisions. Earlier studies in this area have focused on other indicators (Gutiérrez, Jerrim, & Torres, 2020; Murillo, Duk & Garrido, 2018), compared fewer rounds of PISA (Gromada et al., 2019; Le Donne, 2014; Luongo, 2015), focused on a specific country (Haeck & Lefebvre, 2021; Hanushek et al., 2020; Zhou & Jong, 2020), or combined these features. To the best of our knowledge, this is the first study that uses the data from 2000 to 2018 for all the countries that participated in PISA, evaluating the change in their equity over this period. The data from the 2022 PISA wave was purposefully not included in this study, due to the likely significant impact of the COVID-19 pandemic (which included school lockdowns) on educational equity outcomes. As the main objective of the present study is to explore and assess how have countries fared in their equity levels since they started to participate in PISA, the inclusion of the 2022 data would have likely (negatively) influenced the trendlines and acted as a major confounding factor.

Although this study is exploratory in nature, we would expect to see a general increase in countries' equity levels. As already mentioned, equity is — after performance — an important focus of PISA reports (one might argue, of the whole PISA endeavour), as it is a crucial dimension of educational systems. Furthermore, the OECD has consistently highlighted that performance and equity are complementary rather than competing features (Schleicher, 2017). Consequently, it would be expected that countries took advantage of PISA's data and insights in order to foster equity. To be sure, the improvement in countries' indicators (on performance as well as equity) is part and parcel of the PISA enterprise. Additionally, one could expect to see steeper improvements in countries with higher levels of inequity, since, on the one hand, they have more room to improve and, on the other, they would be more pressured to act on their (comparatively) negative indicators. Lastly, we were generally interested in any specific pattern that the analyses might reveal, such as regional trends or between OECD countries and partners.

4. Methodology

4.1. Study sample

We collected data from 87 countries featured in the PISA reports, including 37 OECD members and 50 partner countries. However, only 71 countries have at least two observation points, allowing us to track some dynamic change over time. Furthermore, an even smaller subset of countries has sufficient observations to calculate the significance of trends and standard errors. Only 30 countries feature a complete set of observations spanning all six PISA waves; 7 countries participated in 5 waves of PISA, 16 in 4 waves, 9 in 3 waves, 9 in 2 waves and 16 countries participated only in one wave of PISA. The complete list of countries and

[1] The weighted number of students participating in PISA divided by the total population of 15-year-old students.

[2] PISA scales are divided into proficiency levels, where level 2 is the minimum baseline to solve real-life problems. Students below level 2 are referred to as 'low performers' in the PISA reports. Studies show that they are less likely to complete higher education and attain better-paying and prestigious jobs in the future (OECD, 2023).

the respective number of waves is available in Appendix 2.

4.2. Study design, procedures, and data analysis

To explore trends in equity, we analysed the values for equity indicators drawn from official PISA reports. This study presents a secondary data analysis based on the OECD statistics (available on the published reports). Initially, we have considered the use of multilevel modelling. However, as our analysis focuses on the countries per se, we judged our current (more parsimonious) approach to be more suitable. Furthermore, the use of multilevel modelling when few cases are available for nesting, as would be the case with the PISA waves/years (i.e., $N = 7$), should be carefully considered, with some authors cautioning against their use (Bryan & Jenkins, 2016). Despite autocorrelation is often considered a challenge in time-series analysis, research suggests that with limited observations, corrections for autocorrelation may not be appropriate, and complex statistical models can be inadequate (Mizon, 1995; Wooldridge, 2016). In these cases, linear regression provides a straightforward approach to modelling time-series data, especially when trends are linear, and interpretability is important. Although linear regression's effectiveness is constrained by its assumptions of linearity and limited capacity to capture complex patterns, it works well when simplicity and initial insights are prioritized.

4.2.1. Measurement of equality of opportunity

We focused on one specific indicator of equity: the share of variance in PISA scores that can be explained by the students' Economic, Social, and Cultural Status (ESCS), also known as R-squared (R2). This is arguably the most used indicator of equity, found in many studies and all the PISA reports. ESCS is a composite variable calculated by the OECD, that "has traditionally been built as a weighted average of three indices: parental educational attainment (in years), parental occupational status on the "International Socio-Economic Index" (ISEI) scale (Ganze- boom 2010; Ganzeboom et al. 1992), and a measure of "household possessions". Two of the three components that inform the composite score of ESCS—parental years of education and parental occupational status—coincide with those used "traditionally", according to Cowan et al. (2012). The third component—an index of household possessions, based on the possession or consumption of durable goods—can be thought of as a measure of the household's income, or more precisely, of its "permanent" component (Friedman 1957)" (Avvisati, 2020, p. 4).

To retrieve these data, we searched the official PISA reports and supplementary materials published by the OECD. The complete list of the sources is presented in the Appendix 1.

For each PISA wave from 2000 to 2018, we retrieved the values of R2 for every subject and every participating country. Since early reports did not present the necessary data, we used the 2006 report as a data source for the waves of 2000 and 2003, as it published the required indicators retrospectively. Our data collection process was comprehensive, encompassing all years and subjects, except for the 2009 wave, which only featured data for reading so we excluded it from the analysis to maintain data consistency.

For every participating country, three equity indicators were retrieved from the reports – R2 values in Reading, Mathematics, and Science for every year of PISA. Next, an average of these 3 values was calculated to define the general level of equity for every country in each year/wave. Consequently, our analysis encompasses a total of four indicators: one for each of the three academic subjects and one for the average equity level. We used the average R2 (across Reading, Math and Science) for theoretical and empirical reasons. Theoretically, the option is justified since we are aiming at measuring equity in general instead of equity regarding Math, Science, or Reading separately. This means that the aggregation of the different R2 provides a more robust indicator of equity within each country than the use of three narrower indicators. Hence, we argue that the use of the average R2 provides a more appropriate measure for each country's level of equity.

Furthermore, this approach is empirically supported by the high correlations between countries' R2 across different subjects. Specifically, correlations ranging from 0.81 to 0.94 indicate that the measures of equity in various subjects are highly correlated and can thus be justifiably aggregated into a single average indicator. In fact, this reasoning underpins the validation process of constructs that are not directly observable (Little, 2024; Urbina, 2014), and it has also been applied specifically in the context of PISA subjects (Pokropek, Marks & Borgonovi, 2022, 2022).

4.2.2. Measurement of trends in equity (Equality of opportunity)

Next, we calculated the trends in equity for each country using linear regression analysis. For each country case, four separate regressions were calculated for each of the subjects (Math, Reading, Science) and an average indicator. Simple linear regression is a basic statistical method used to understand the relationship between two variables. In our case, the dependant variable (an indicator of equity on a national level) is predicted based on the value of an independent variable, which is the year of observation. The numbering of the years started from the first round of PISA, with the year 2000 coded as 0, the year 2003 as 3, and so on. The change in equity is represented by the equation:

$$Y = \beta_0 + \beta_1 X + e$$

Where:

- Y is the predicted value of equity on a national level.
- β_0 is the intercept of the regression (the predicted value of equity on a national level at the beginning of observations, the year 2000 was coded as 0).
- β_1 is the slope of the regression line (the change in equity for a one-unit change in X, meaning one year of observation).
- e represents the error term, accounting for the variation in Y that is not explained by X.

This way, the intercept represents the predicted value that each country would have in the year 2000, and the β_1 coefficient (slope) indicates the change in equity per year. This approach enabled us to determine the direction and magnitude of equity trends over time in a systematic manner. In this way, regression β_1 coefficient is used to gauge the direction of equity changes over time. If the coefficient is positive, the share of explained variance increases, suggesting a decrease in equity. And vice versa, if the slope is negative, it indicates that equity is rising. When it is close to zero, it suggests that only minimal changes in equity have occurred over the observed period. In practical terms, the β_1 coefficient shows the change in the R2 indicator per year during the observed period. This indicator can be calculated if a country has a minimum of 2 observations over time. However, the reliability of the calculations increases when the number of observations is bigger.

As a part of this analysis, we also computed standard errors and assessed the statistical significance of the trends. Calculating these values requires at least 3 observation points for each country. Smaller standard errors and statistical significance below 0.05 indicate robustness in the trends. Nevertheless, our dataset contains a relatively limited number of observations per country. Therefore, it is prudent to approach the interpretations cautiously, considering the statistical aspects and visual analysis of the trend lines to ensure a comprehensive understanding of the data.

Thus, we computed the direction and significance of equity trends for each country and subsequently synthesised these results to uncover overarching patterns. The analysis was executed using IBM SPSS statistics version 29 and Microsoft Excel. The full list of countries and their respective results can be found in Appendix 2.

5. Results

Next, the trend was calculated for each country, including the statistical significance and the standard error for the cases in which the data

were available. The summary of this step is presented in Fig. 1, where the right side of the diagram indicates the number of countries that show an improvement in a country's equity level, and the left side of the diagram summarises the countries that show a decrease in equity level. Overall, more countries exhibit positive changes in equity, although these trends were statistically significant for a minority of them. Upon closer inspection at the country level, we see that equity is not gradual but rather characterised by periodic fluctuations (ups and downs). In this context, statistical significance highlights the cases where observations align more closely with the theoretical trend line, signifying greater consistency in the observed changes.

The proportion of countries exhibiting positive and negative trends varies slightly depending on the subject. For example, equity improved in 54 countries in Mathematics, 49 in Reading, and 48 in Science. When we aggregate the data from all three subjects into an average equity indicator, 51 countries show positive trends. This suggests that low equity might be attributable to structural and contextual factors at play within each country, such as the organisation of the educational system, teachers' training, or the overall level of social inequality.

While the overall direction of the trend may be positive, the presence of fluctuations and gaps in the data prevents us from drawing conclusions regarding the stability and consistency of these changes. In this study, we label such situations as 'No changes', which means that the changes are either inconsistent or not significantly different from zero. The same logic applies to reading, science, and the average of the three subjects. In all these cases, only a few instances enable us to assert that the observed changes are robust and reliable.

The distribution of the countries based on the intensity and the direction of change in equity (measured as B coefficients or regression slope) appears to follow a normal distribution pattern, with values mostly centred around zero, as shown in Fig. 2. The distributions are similar across different PISA subjects. However, there are differences when we compare OECD countries to non-OECD countries. In the OECD countries, equity changes tend to cluster closer to zero, indicating that these countries experience smaller fluctuations in equity, whether positive or negative. On the other hand, non-OECD countries present a broader spectrum of equity shifts, including both negative and positive changes. This contrast can be attributed to the number of observations in some non-OECD nations. Nevertheless, it may also point towards greater diversity in trajectories and the potential for more pronounced changes in equity within non-OECD countries.

These trends become more obvious when plotted on a map showing disparities in equity between the countries (Fig. 3). We selected the average of the three PISA subjects to illustrate these changes. Small differences may emerge depending on the chosen equity indicator, as the difference between the statistically significant and insignificant results can be very subtle. That said, the map summarises the general tendencies of equity change worldwide. In most countries, over the last two decades, there has been some positive shift in equity. However, most of these changes lack robustness and statistical significance. Equity improvements are seen in countries spread out across continents, each with different cultures and differing GDP averages.

The map also highlights blank spots where information is unavailable, largely because these countries did not participate in PISA. These countries are mostly located in regions characterised by high societal inequalities (Africa, the Middle East, and Asia). It emphasises the importance of further research in these regions to monitor their educational equity level accurately.

One crucial factor to consider while interpreting the change in equity is the overall average equity level within a country. In theory, it is easier to cultivate changes in equity where more room for improvement exists. This means that countries with lower equity levels have more opportunities for improvement, so we also took the overall level of equity when interpreting the results.

As some countries were introduced to the PISA program at later stages and were missing data for the earliest waves, we applied the average level of equity for the entire observation period as an indicator of the overall equity of a country. The changes in equity and the average equity level are presented in Fig. 4. The horizontal axis is the change in equity based on the mean of three PISA subjects. The x-axis scale is different for the OECD and non-OECD countries to make the visualisation more readable. A country's overall average level of equity is depicted on the vertical axis. It is an average R2 value for each country based on all the available rounds of observations. The grey band marks the area within ± 1 standard deviation from the mean to indicate the average values. For better readability, the axes are inverted to show smaller values as weaker relationships between ESCS and achievement – reflective of better outcomes. Conversely, the bigger values represent negative trends. Distinct symbols highlight significant changes.

The results show the average equity level of the country over the observation period (vertical axis) and its change over the past two decades (horizontal axis). We can see that most countries are clustered within ± 1 standard deviation from the average level of equity (OECD mean = 13.9, SD = 3.8, Non-OECD mean = 11.5, SD = 4.26), with few countries located much higher or lower than this. It shows a degree of homogeneity in the average level of equity across countries. Also, most countries have not shown significant changes in either direction. As previously discussed, within OECD countries, the indicators of changes tend to be close to zero, meaning a narrower range of changes. However, a higher proportion of these changes are statistically significant. This

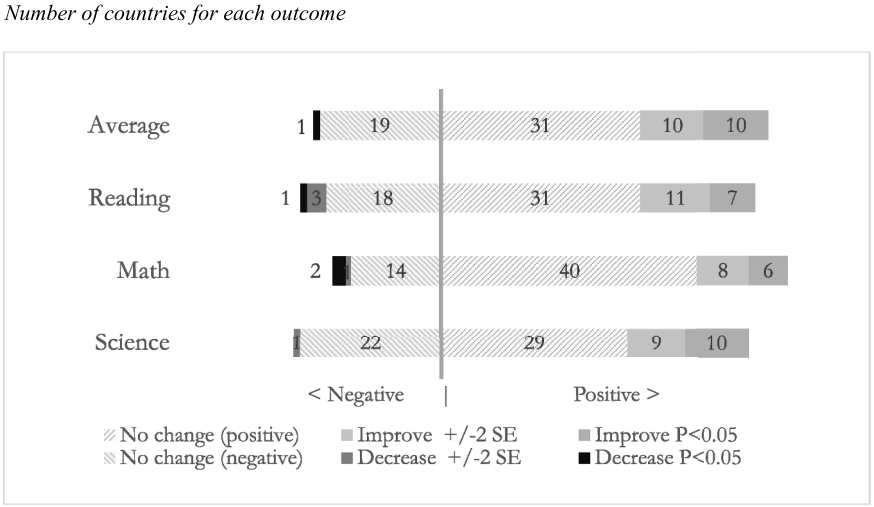

Fig. 1. Number of countries for each outcome.

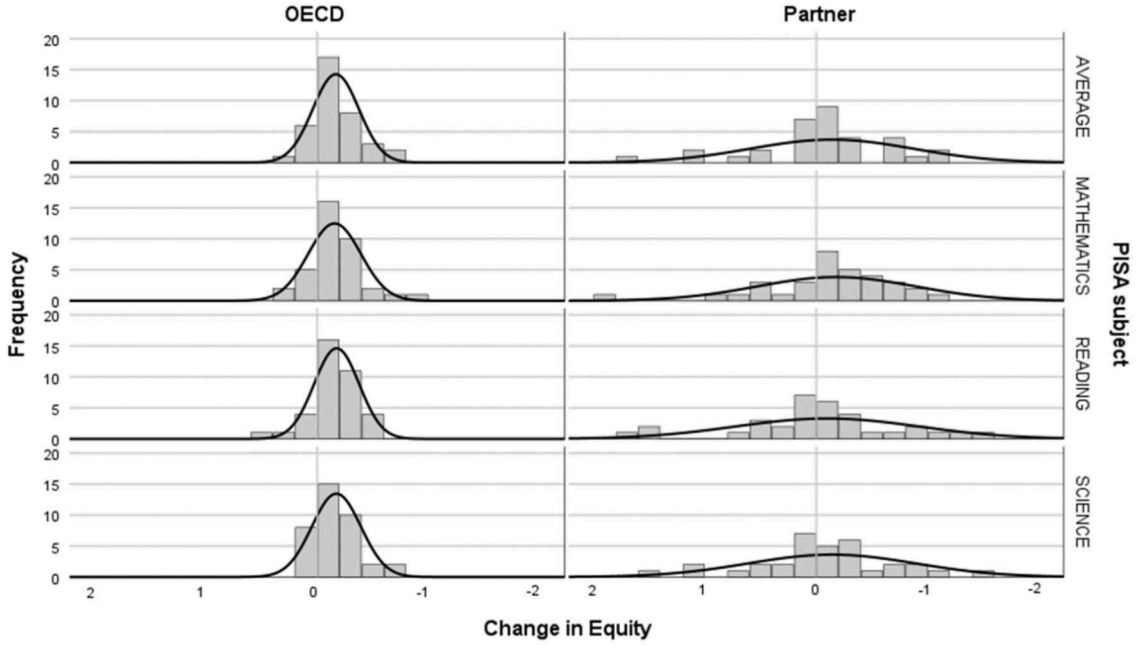

Fig. 2. Distribution of OECD and Partner countries based on the change in equity.

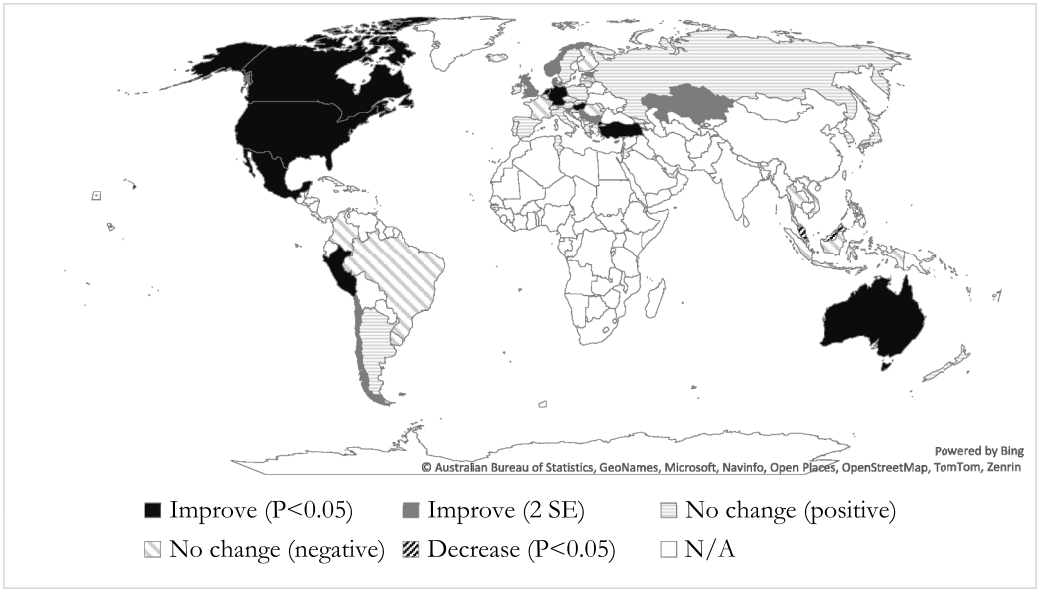

Fig. 3. Geography of changes in equity (based on the average of PISA subjects).

can be attributed to the larger number of observations within OECD countries, but it may also signify more consistent changes in these nations.

Interestingly, Malaysia stands out as the sole country with a statistically significant negative trend. On the other side, 10 countries have significantly improved their equity levels. These are Australia, Canada, Germany, Hungary, Mexico, the United States, the Netherlands, and Turkey in the OECD group, as well as Hong Kong (China) and Peru in the non-OECD group. If we consider a double standard error interval as a measure of importance, we can add 10 more countries to the list, namely Denmark, Norway, Chile, Estonia, Slovenia, and the United Kingdom in the OECD group, and Bulgaria, Cyprus, Kazakhstan, and Serbia in the non-OECD group. In the OECD group, there are no countries with significant negative trends.

Notably, most countries in the analysis present an average level of equity and a small magnitude of the changes. However, it is fundamental to acknowledge that countries with low equity levels, such as Hungary, Peru, Germany, Chile, and Bulgaria, managed to improve. In contrast, despite having low levels of equity, Luxembourg and France did not manage to improve significantly over the years. Additionally, it is remarkable that some countries, even with high initial equity levels, have managed to enhance their equity further, including Estonia, Kazakhstan, and Hong Kong.

6. Discussion and implications

This study analyses data from the 2000 to 2018 PISA rounds, offering an overview of educational socioeconomic-related equity trends across 87 countries, comprising 37 OECD members and 50 partner countries. It offers insights into the dynamics of equity levels at the country level, the

Change in equity and the average level of equity (based on the average of PISA subjects)

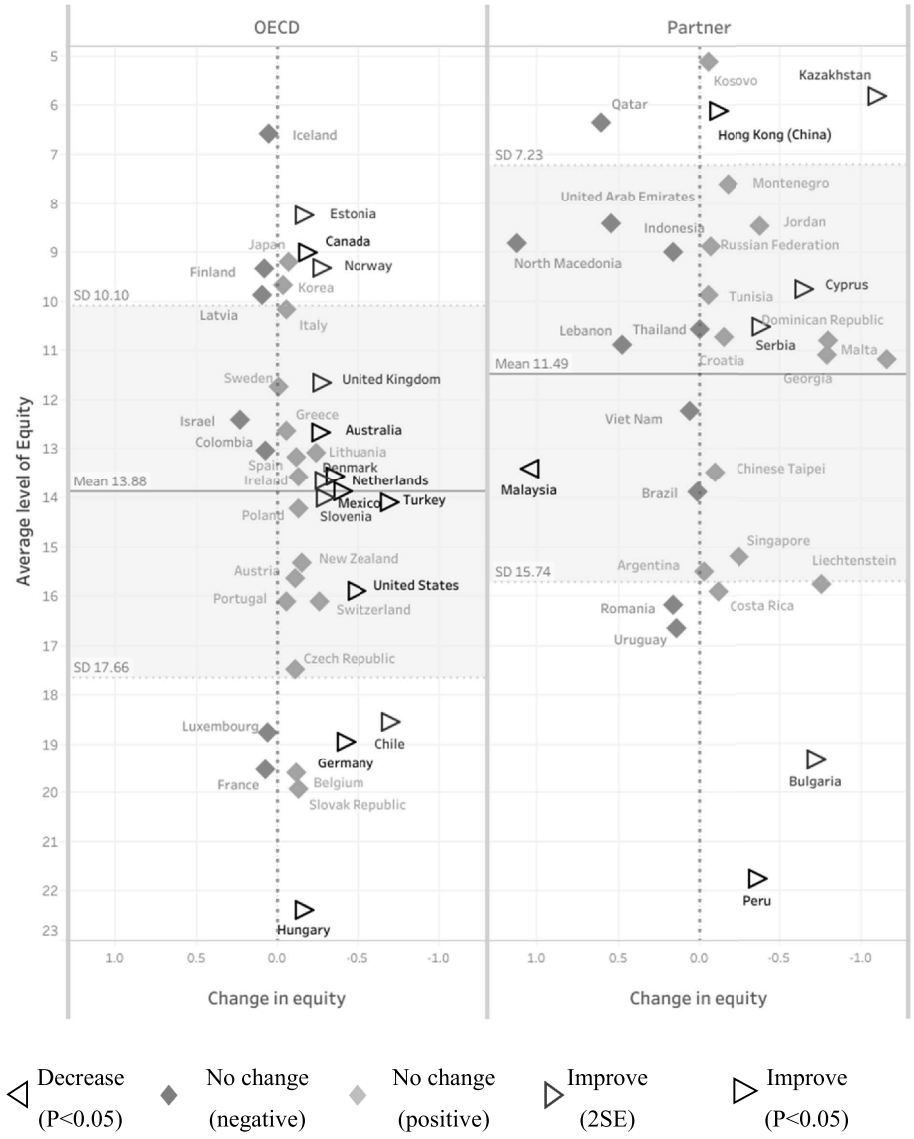

Fig. 4. Change in equity and the average level of equity (based on the average of PISA subjects).

stability of these trends, and the consistency of the changes.

First, it is important to notice the differences between countries in the proportion of variance of scores explained by the students' socio-economic background: from approximately 5% up to more than 22%, i.e., a fourfold gap. This simple acknowledgement renders evident the fact that some countries are able to do much better than others. Consequently, as we are speaking about equity and young students, it should not be controversial to state that countries with low equity levels are morally obliged to do their best in order to weaken the relationship between socioeconomic status and students' results.

The present study shows that, on average, PISA participating countries have (slightly) improved their equity levels (as measured by the R2 indicator). This is a reason for some optimism. From 2000 to 2018, the average R2 in the OECD countries has decreased from 15% to 12.8%, indicating an overall tendency to disrupt this connection. Nevertheless, there is a clear divergence in equity trends across different countries. Although many countries show positive shifts in equity levels, most face difficulties in making progress. Even when there is an overall positive direction in equity trends, these changes are often not robust or consistent enough to be considered statistically significant.

Furthermore, this study also helps to identify successful country cases that have demonstrated solid and coherent positive trends in improving educational equity over the last two decades. Although these cases are not confined to specific geographical regions or economic contexts, the OECD members have a significantly higher proportion of successful cases compared to the overall number of countries in the group. For instance, 8 out of 37 OECD countries (21.6%) exhibit a statistically significant positive equity trend, compared to only 2 out of 34 (5.9%) non-OECD countries (the number of OECD countries that have enough observations to calculate the significance of the trend). However, this result should be interpreted considering that OECD countries, on average, have a longer history of participating in PISA and, therefore, provide more observations that help evaluate the statistical significance of the trends. Also, OECD countries show smaller fluctuations in equity, indicating more stable trends, while non-OECD countries show a broader range of positive and negative changes. On the other hand, it is also noteworthy that partner countries show, on average, better levels of equity. The average level of equity (average R2 over the whole period of

observations) is 11.5 in the partner countries compared to 13.9 in the OECD countries.

The study highlights the diversity of national pathways to equity. Some countries with low levels of educational equity have made significant progress, while others with better equity levels struggle to advance further. This underscores the importance of analysing the specific contexts when assessing equity. In PISA reports, traditionally, attention is focused on the overall rankings of the countries. However, focusing on the countries at the top of the list can be counterproductive. Their experience may be less relevant to other countries, and they are not necessarily those that have made the most progress. Thus, it may be fruitful to explore the experience of countries that have made significant progress in their equity levels and identify the educational policies that have led to such changes. Understanding the experience of those countries can be crucial for global efforts to promote equitable education.

Perhaps the most noteworthy finding of the current study is the absence of clear patterns regarding the relation between equity levels and equity change, on the one hand, or change in equity and other variables. As seen above, countries across the equity spectrum have been able to improve their equity levels, and no pattern can be identified (e.g., countries with low equity levels increasing more than countries with already high equity). Furthermore, it is worth noting that the countries with positive changes in equity span different continents and have diverse levels of economic development. This underscores that positive results can be achieved regardless of these factors. Positive changes are not confined to any specific region, cultural context, or equity level, perhaps indicating that it is within every country's power to improve its equity level. One might state that this is, in itself, an equitable finding. It is important to notice that both the OECD and several other authors argue that there is no trade-off between efficacy and equity; rather, performance and equity seem to go hand-in-hand (Duru-Bellat, 2012; Lingard, Sellar & Savage, 2014; OECD, 2013; Schleicher, 2017).

Lastly, it is important to consider how the results presented here concur and/or contrast with and add to the current body of knowledge. As seen in the literature review of the present study, the most comprehensive study regarding change in equity (using PISA data) is the recent systematic review by Enchikova et al. (2024). This review concluded that the literature is considerably scattered and inconsistent in its findings, both across equity dimensions and within each dimension, such as equality of opportunity. Several factors were considered for these inconsistencies, including the use of different variables/indicators, different waves and time-frames, different subjects (Reading, Math and Science), and often loose (if any) cut-off criteria when assessing equity trends. The current study represents a considerable effort to address these caveats, namely by using all the available PISA waves for each participating country and calculating an average R-square between subjects, rendering the results more stable and representative of the "real" general equity level (i.e., less dependant on a specific subject). Additionally, the study also addresses an additional caveat identified in the review, namely by combining the "absolute" position in the equity indicator with the change across time in that same indicator. Given all these factors, the present study is, to the best of our knowledge, the first attempt of its kind, adding to the existing literature a first comprehensive picture of the evolution of equality of opportunities (assessed trough the R-squared indicator) in PISA participating countries.

While we can celebrate the positive improvements in some countries, we must not overlook the remaining challenges in achieving equity worldwide. Even in countries with positive dynamics, the connection between Economic, Social, and Cultural Status (ESCS) and educational outcomes still exists, proving that pursuing equity in education remains an ongoing endeavour, calling for further research and political efforts to address this complex issue comprehensively.

7. Limitations and future research

This study has some limitations that need to be considered in order to understand and interpret the results better. First, it focuses on a single equity indicator (although comparing it in different school subjects). While R2 can be used to measure the connection between the ESCS and educational outcomes, and it is arguably the most well-known and used equity indicator of PISA, it does not fully capture the multifaceted structure of equity (Nata, Enchikova, Toledo & Neves, 2022). Thus, one should not take the data presented here as a complete picture of the countries' equity levels or their change. In fact, future research must add to the current work by providing the same type of analysis for different equity indicators (e.g., inequality of outcomes and segregation). Confronting different indicators of educational equity with the current one (i.e., R2) will certainly bring a more nuanced and complex image of the evolution of equity.

It is also relevant to highlight that the quality of the data is not the same for all countries. Most notably, there are several countries for which there is limited data, namely due to their participation in a small number of PISA rounds. This limitation is clearly more pronounced in the poorest countries, often classified as "partners".

Another limitation is the comparability between different rounds of PISA. Although we use the same indicators for all the rounds, PISA's assessment tools and data collection methods have evolved over the past 20 years. Although the creators of PISA have put effort into ensuring comparability from one cycle to the next, the comparability of data over the whole period is still under debate (Avvisati, 2020; Treviño et al., 2021). Nevertheless, PISA is currently one of the most comprehensive and coherent sources of data on educational equity, covering a broad range of countries and a large time frame. Future research should address these limitations by exploring methods to enhance the comparability of PISA rounds, particularly the data underlying the ESCS indicator (as well as other socioeconomic-related indicators). This would provide a more nuanced and accurate understanding of global educational equity trends.

Declaration of generative AI and AI-assisted technologies in the writing process

While preparing this manuscript, the authors used Grammarly and ChatGPT to correct grammar and ensure better text flow. After using this tool/service, the authors reviewed and edited the content and took full responsibility for the publication's content.

CRediT authorship contribution statement

Ekaterina Enchikova: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tiago Neves:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Cibelle Toledo:** Writing – review & editing, Conceptualization. **Gil Nata:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work is funded by The Foundation for Science and Technology, Fundação para a Ciência e a Tecnologia, IP (FCT), within "Equity&PISA: Equity through PISA: results and discourses" project grant no. PTDC/CED-EDG/2124/2020 with the DOI 10.54499/PTDC/CED-EDG/2124/2020. It was also partially supported under the multi-year funding awarded to CIIE grant no. UIDB/00167/2020 and UIDP/00167/2020. Gil Nata was supported by the FCT (Fundação para a Ciência e a

Tecnologia) grant CEECIND/00646/2018/CP1544/CT0001; with the respective DOI reference 10.54499/CEECIND/00646/2018/CP1544/CT0001.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijedro.2025.100445.

References

Agasisti, T., Avvisati, F., Borgonovi, F., & Longobardi, S. (2021). What school factors are associated with the success of socio-economically disadvantaged students? An empirical investigation using pisa data. *Social Indicators Research*. https://doi.org/10.1007/s11205-021-02668-w

Ainscow, M. (2020). Promoting inclusion and equity in education: Lessons from international experiences. *Nordic Journal of Studies in Educational Policy, 6*(1), 7–16. https://doi.org/10.1080/20020317.2020.1729587

Ali, F., Ow-Yeong, Y. K., & Tilley, J. L. (2024). Are schools becoming more unequal? Insights from exploratory data mining of international large-scale assessment, TIMSS 2003–2019. *Studies in Educational Evaluation*. https://doi.org/10.1016/j.stueduc.2024.101241

Anderson, G., Fruehauf, T., Pittau, M., & Zelli, R. (2015). *Evaluating progress toward an equal opportunity goal: Assessing the german educational reforms of the first decade of the 21st century*. University of Toronto, Department of Economics, Working Papers. https://ideas.repec.org/p/tor/tecipa/tecipa-552.html.

Anderson, G., Pittau, M. G., & Zelli, R. (2020). Measuring the progress of equality of educational opportunity in absence of cardinal comparability. *Metron, 78*(2), 155–174. https://doi.org/10.1007/s40300-020-00172-8

Appels, L., De Maeyer, S., Faddar, J., & Van Petegem, P. (2023). Unpacking equity. Educational equity in secondary analyses of international large-scale assessments: A systematic review. *Educational Research Review, 38*, 100494.

Avvisati, F. (2020). The measure of socio-economic status in PISA: A review and some suggested improvements. In *Large-Scale assessments in education, 8*. Springer. https://doi.org/10.1186/s40536-020-00086-x

Bryan, M. L., & Jenkins, S. P. (2016). Multilevel modelling of country effects: A cautionary tale. *European Sociological Review, 32*(1), 3–22. https://doi.org/10.1093/esr/jcv059

Bulkley, K. E. (2013). Conceptions of Equity: How Influential Actors View a Contested Concept. *Peabody Journal of Education, 88*(1), 10–21. https://doi.org/10.1080/0161956X.2013.752309

Davidov, E., Meuleman, B., Cieciuch, J., Schmidt, P., & Billiet, J. (2014). Measurement Equivalence in Cross-National Research. *Annual Review of Sociology, 40*(1), 55–75. https://doi.org/10.1146/annurev-soc-071913-043137

Duru-Bellat, M. (2012). Leveling the Learning Bar in Secondary School Across Social Class. In J. Heymann, & A. Cassola (Eds.), *Lessons in educational equality: Successful approaches to intractable problems around the world* (pp. 101–115). https://doi.org/10.1093/acprof:oso/9780199755011.003.0005

Enchikova, E., Neves, T., Toledo, C., & Nata, G. (2024). Change in socioeconomic educational equity after 20 years of PISA: A systematic literature review. *International Journal of Educational Research Open, 7*, Article 100359. https://doi.org/10.1016/j.ijedro.2024.100359

Espinoza, O. (2007). Solving the equity–equality conceptual dilemma: A new model for analysis of the educational process. *Educational Research, 49*(4), 343–363. https://doi.org/10.1080/00131880701717198

Gromada, A., Rees, G., & Chzhen, Y. (2019). Comparing inequality in adolescents' reading achievement across 37 countries and over time: Outcomes versus opportunities. *Compare: A Journal of Comparative and International Education, 51*(4), 495–511. https://doi.org/10.1080/03057925.2019.1640597

Gutiérrez, G., Jerrim, J., & Torres, R. (2020). School Segregation Across the World: Has Any Progress Been Made in Reducing the Separation of the Rich from the Poor? *Journal of Economic Inequality, 18*, 157–179. https://doi.org/10.1007/s10888-019-09437-3

Haeck, C., & Lefebvre, P. (2021). Trends in Cognitive Skill Inequalities by Socio-Economic Status across Canada. *Canadian Public Policy, 47*(1), 88–116. https://doi.org/10.3138/cpp.2019-039

Hanushek, E. A., Peterson, P. E., Talpey, L. M., Woessman, L., Harvard University, P., on, E. P., & Governance. (2020). *Long-Run trends in the U.S. SES-Achievement gap. program on education policy and governance working papers series. pepg 20-01*. Program on Education Policy and Governance. https://doi.org/10.3386/w26764

Holgado-Aguadero, M., Martínez-Abad, F., & Hernández-Ramos, J.-P. (2024). Estudio de factores sociodemográficos asociados a la inequidad educativa en la Educación Secundaria en España. Un análisis de las pruebas PISA. *Estudios Sobre Educación*. https://doi.org/10.15581/004.49.002

Krüger, N. (2014). Beyond access: Social segregation and inequality in the argentine education system. *Cuadernos de Economia (Colombia), 33*(63), 513–542. https://doi.org/10.15446/cuad.econ.v33n63.45344

Krüger, N. (2019). Socioeconomic school segregation as a dimension of educational exclusion: Fifteen years of evolution in Latin America. *Education Policy Analysis Archives, 27*(8), 1–33. https://doi.org/10.14507/epaa.27.3577

Le Donne, N. (2014). European Variations in Socioeconomic Inequalities in Students' Cognitive Achievement: The Role of Educational Policies. *European Sociological Review, 30*(3), 329–343. https://doi.org/10.1093/esr/jcu040

Lenkeit, J., Schwippert, K., & Knigge, M. (2017). Configurations of multiple disparities in reading performance: Longitudinal observations across France, Germany, Sweden and the United Kingdom. *Assessment in Education: Principles, Policy & Practice, 25*(1), 52–86. https://doi.org/10.1080/0969594X.2017.1309352

Lingard, B., Sellar, S., & Savage, G. C. (2014). *Re*-articulating social justice as equity in schooling policy: The effects of testing and data infrastructures. *British Journal of Sociology of Education, 35*(5), 710–730. https://doi.org/10.1080/01425692.2014.919846

Little, T. D. (2024). Longitudinal structural equation modeling. *Longitudinal structural equation modeling* (2nd ed.). New York: The Guilford Press.

Luongo, P. (2015). *Inequality of opportunity in educational achievements: Cross-country and intertemporal comparisons*. Helsinki: UNU-WIDER: World Institute for Development Economic Research (UNU-WIDER), WIDER Working Paper 2015/043.. https://doi.org/10.35188/UNU-WIDER/2015/928-2

Marrero, G. A., Palomino, J. C., & Sicilia, G. (2024). Inequality of opportunity in educational achievement in Western Europe: Contributors and channels. *Journal of Economic Inequality, 22*(3), 383–410. https://doi.org/10.1007/s10888-023-09595-5

Martínez-Abad, F., Crespi, M. C., Mikulic, I. M., & Holgado-Aguadero, M. (2024). Evolución de la Inequidad y Segregación Socioeconómica en la Educación Secundaria Argentina. *REICE. Revista Iberoamericana Sobre Calidad, Eficacia Y Cambio En Educación, 22*(4), 165–187. https://doi.org/10.15366/reice2024.22.4.009

Mizon, G. E. (1995). A simple message for autocorrelation correctors: Don't. *Journal of Econometrics, 69*(1), 267–288. https://doi.org/10.1016/0304-4076(94)01671-L

Murillo, F. J., Duk, C., & Garrido, C. M. (2018). The evolution of socio-economic segregation of Latin American schools. *Estudios Pedagogicos, 44*(1), 157–179. https://doi.org/10.4067/S0718-07052018000100157

Nata, G., Enchikova, E., Toledo, C., & Neves, T. (2022). PISA and equity change: A scoping review. *Revista Lusófona de Educação, 56*(56), 65–80. https://doi.org/10.24140/issn.1645-7250.rle56.05

OECD. (2003). *Literacy skills for the world of tomorrow: Further results from PISA 2000*. Paris: OECD Publishing. https://doi.org/10.1787/9789264102873-en

OECD. (2004). *Learning for Tomorrow's World: First results from PISA 2003, PISA,*. Paris: OECD Publishing. https://doi.org/10.1787/9789264006416-en

OECD. (2007). *PISA 2006: Science Competencies for Tomorrow's World. 1*. Analysis, PISA, Paris: OECD Publishing. https://doi.org/10.1787/9789264040014-en

OECD. (2010). *PISA 2009 Results: Overcoming Social Background: Equity in Learning Opportunities and Outcomes. II*. PISA, Paris: OECD Publishing. https://doi.org/10.1787/9789264091504-en

OECD. (2013). PISA 2012 Results: Excellence through Equity, *II. Giving Every Student the Chance to Succeed*. OECD Publishing: PISA, Paris. https://doi.org/10.1787/9789264201132-en

OECD. (2017a). *Starting Strong 2017: Key OECD Indicators on Early Childhood Education and Care, Starting Strong*. Paris: OECD Publishing. https://doi.org/10.1787/9789264276116-en

OECD. (2017b). *Where did equity in education improve over the past decade?*. Paris: OECD Publishing. https://doi.org/10.1787/33602e45-en

OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education, PISA,*. Paris: OECD Publishing. https://doi.org/10.1787/53f23881-en

OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education*. Paris: PISA. https://doi.org/10.1787/9789264266490-en

OECD. (2019). *PISA 2018 results (Volume II): Where All Students Can Succeed*. Paris: PISA, OECD Publishing. https://doi.org/10.1787/b5fd1b8f-en

Oppedisano, V., & Turati, G. (2012). What Are the Causes of Educational Inequality and of Its Evolution over Time in Europe? Evidence from PISA. *Education Economics, 23*(1–2), 3–24. doi: 10.1080/09645292.2012.736475..

Pokropek, A., & Borgonovi, F. (2020). Linking via Pseudo-Equivalent Group Design: Methodological Considerations and an Application to the PISA and PIAAC Assessments. *Journal of Educational Measurement, 57*(4), 527–546. https://doi.org/10.1111/jedm.12261

Pokropek, A., Marks, G. N., Borgonovi, F., Koc, P., & Greiff, S. (2022). General or specific abilities? Evidence from 33 countries participating in the PISA assessments. *Intelligence, 92*, 1–13. https://doi.org/10.1016/j.intell.2022.101653

Pokropek, A., Borgonovi, F., & McCormick, C. (2017). On the Cross-Country Comparability of Indicators of Socioeconomic Resources in PISA. *Applied Measurement in Education, 30*(4), 243–258. https://doi.org/10.1080/08957347.2017.1353985

Pokropek, A., Marks, G. N., & Borgonovi, F. (2022). How Much Do Students' Scores in PISA Reflect General Intelligence and How Much Do They Reflect Specific Abilities? *Journal of Educational Psychology, 114*(5), 1121–1135. https://doi.org/10.1037/edu0000687

Rutkowski, D., & Rutkowski, L. (2013). Measuring socioeconomic background in PISA: One size might not fit all. *Research in Comparative and International Education, 8*(3), 259–278. https://doi.org/10.2304/RCIE.2013.8.3.259

Schleicher, A. (2009). Securing quality and equity in education: Lessons from PISA. *Prospects, 39*(3), 251–263. https://doi.org/10.1007/s11125-009-9126-x

Schleicher, A. (2017). Seeing education through the prism of PISA. *European Journal of Education, 52*(2), 124–130. https://doi.org/10.1111/ejed.12209

Sulis, I., Giambona, F., & Porcu, M. (2020). Adjusted indicators of quality and equity for monitoring the education systems over time. Insights on EU15 countries from PISA surveys. *Socio-Economic Planning Sciences, 69*, 100805. https://doi.org/10.1016/j.seps.2019.05.005

Treviño, E. Sandoval-Hernández, Miranda, A., Rutkowski, D., & D. Matta, T. (2021). Invariance of Socioeconomic Status Scales in International Studies. In J. Manzi, M. R. García, & S. Taut (Eds.), *Validity of Educational Assessments in Chile and Latin America*. Cham: Springer. https://doi.org/10.1007/978-3-030-78390-7_10.

UNESCO. (2017). *A guide for ensuring inclusion and equity in education* (p. 46). Paris: United Nations, Educational, Scientific and Cultural Organization. https://doi.org/10.54675/MHHZ2237

United Nations. (1948). *Universal declaration of human rights*. Paris: United Nations. https://www.un.org/en/about-us/universal-declaration-of-human-rights.

United Nations. (1962). *Convention against discrimination in education, Paris: United Nations*. https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-against-discrimination-education.

United Nations. (1989). *Convention on the rights of the child. New York: United Nations*. https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-rights-child.

United Nations. (1966), *999. International Covenant on Economic, Social, and Cultural Rights* (p. 171). New York: United Nations. Treaty Series. https://www.ohchr.org/sites/default/files/cescr.pdfhttps://www.ohchr.org/sites/default/files/cescr.pdf.

United Nations. (2023). *The Sustainable Development Goals Report: 2023*. New York: United Nations. https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf.

Unterhalter, E. (2009). What is equity in education? Reflections from the capability approach. *Studies in Philosophy and Education, 28*, 415–424. https://doi.org/10.1007/s11217-009-9125-7

Urbina, S. (2014). *Essentials of psychological testing* (2nd ed.). John Wiley & Sons, Inc. https://doi.org/10.1002/9781394259458

Van de Vijver, F. J. R., Avvisati, F., Davidov, E., Eid, M., Fox, J.-P., Le Donné, N., et al. (2019). *Invariance analyses in large-scale studies, 201*. OECD Education Working Papers. https://doi.org/10.1787/254738dd-en

Wooldridge, J. M. (2016). *Introductory Econometrics: A Modern Approach*. Cengage Learning.

Zhou, X., & Jong, M. S. Y. (2020). From PISA 2009 to PISA 2018: Equity in Hong Kong Secondary Mathematics and Science Education. In *, 2020. Proceedings - 2020 International Symposium on Educational Technology* (pp. 277–279). ISET. https://doi.org/10.1109/ISET49818.2020.00067.