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Trends 1999-2011

Jesús Duarte
Maria Soledad Bos
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Educational Equity in Chile: Trends 1999-2011

Jesús Duarte, Maria Soledad Bos, Martín Moreno and Alejandro Morduchowicz

EDU/SCL[1]

Executive Summary

For over thirty years, Chile has been implementing reforms and policies aimed at improving educational efficiency, quality and equity. The latter has been of particular interest over the last decade. The quality and quantity of data available in Chile allows us to explore the evolution of learning gaps among students according to their socioeconomic background over increasingly longer periods of time. The findings of this study indicate positive changes in the distribution of learning achievement according to student socioeconomic level or, in other words, educational equity. However, the magnitude of these changes varies according to grade level and subject. Changes have been more notable in the fourth grade and in language than in the eighth grade and in math, and they have been minimal in the tenth grade. Furthermore, as a methodological contribution to studies on educational equity, we make use of a variety of tools in order to explore their consistency. Therefore, this document presents, in their respective sections: a) the results of national achievement tests from the past years and an analysis of trends in socioeconomic and academic segregation in schools; b) changes in the relationship of socioeconomic status to academic achievement between and within schools; and c) the evolution in learning gaps between students from different socioeconomic backgrounds.

JEL Code: I24 – Education and Inequality

Key Words: Education, Equity, Gaps, Learning, Chile, Efficiency, Quality, Socio-economic backgrounds, National tests, Education Reform, Indicators, Results, tec.

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Introduction

Since 1980, Chile has implemented a series of large-scale educational reforms initially aimed at increasing access and efficiency on all levels and later designed to improve educational quality and equity. At the beginning of the 1990s, having reached primary and secondary school enrolment objectives, the focus shifted from input to results. Equity was no longer seen as the homogenous availability of resources, but rather measures in favor of the most vulnerable sectors. These reforms were implemented in a context of decentralization and of policies inherited from the previous government, resulting in a combination of market regulation and state policies that persists to this day (see Espínola, 1993; Cox, 1997; Vargas and Peirano, 2002; and Bellei, Contreras and Valenzuela, 2008 and 2010).

Starting in 2000, an even greater emphasis has been placed on improving equity levels. In 2003, for example, secondary school–which lasts four years–became mandatory (previously, this had only applied to the eight years of primary school), increasing concerns regarding the retention of the most vulnerable students. Another important milestone was the introduction of the Preferential School Subsidy (Subvención Escolar Preferencial or SEP) in 2008, which provides additional resources to schools serving vulnerable students, along with requirements for increased accountability of educational quality. That same year saw the introduction of the General Education Act (Ley General de Educación or LGE) which replaced the 1990 Organic Constitutional Law on Education (Ley Orgánica Constitucional de Enseñanza or LOCE). Among other policies, this Act fosters a series of new measures aimed at equity, including a ban on student selection up to the sixth grade in publicly funded schools.

More recently, in 2011 a law was passed establishing the National System of Quality Assurance in Early Childhood, Primary and Secondary Education. This led to the creation of the Superintendency of Education in 2012, which ensures private school owners comply with the new requirements, and of the Agency for Educational Quality. The latter oversees the evaluation of educational achievement, ranking schools according to test results and other educational quality indicators, assessing the performance of schools, principals, owners and administrators, and providing information to the community.

This notable degree of activity on education policy issues has not gone unnoticed by industry analysts; the Chilean education system has generated a prolific amount of data and documentation of its challenges and achievements. Chile has likely prompted more quantitative studies of the quality and equity of its educational system than any other country in the region (see Hsieh and Urquiola, 2006; McEwan, Urquiola and Vegas, 2008; and Mizala, Romaguera and Ostoic, 2004, among others).

However, very few of these studies include long-term analysis (among the exceptions see Hsieh and Urquiola, 2006). Potential reasons for this may include a lack of homogeneity in the data series and test scores, the absence in various studies of some of the variables surveyed and a difficulty in comparing some of the data gathered (scores on the various tests of the Chilean Ministry of Education's quality measurement system or SIMCE were not completely comparable until 1999). However, some of those obstacles have been successfully overcome, at least in the last decade.

With this in mind and considering the current context of policies aimed at improving educational equity, it is therefore relevant to analyze the evolution of the distribution of academic achievement among students of different socioeconomic backgrounds. This study seeks to respond to the following two questions: (i) have gains been made in educational equity in Chile over the last period? and (ii) how significant have the changes in equity been and at what grade levels? To answer these questions, we employed a variety of approaches used in similar international studies. First, we explore whether there have been changes in the socioeconomic and academic segregation of schools. Then we examine the variations over time in the relationship of the socioeconomic status of students and schools and their relation to test scores. And finally, we analyze the evolution of learning gaps among students from different socioeconomic groups. Using these three different approaches allows us to verify whether or not the findings in one case are consistent with the results obtained using other analytic tools. This study focuses on exploring and quantifying potential changes in educational equity. It does not attempt to analyze the causes behind these variations. However, we hope it can be used as input for future studies on the factors that may be causing these variations in educational equity, studies which require methodologies and data that exceed the scope of this paper.

This document is divided into three sections. In the first, we present the scores reported for the national tests over the last decade and analyze trends in socioeconomic and academic segregation in schools. The second addresses the evolution of differences in test scores between and within schools and their relationship to the socioeconomic status of students. And finally, in the third we present the results of the analysis of the evolution of learning gaps between students of different socioeconomic groups.

1. Evolution of SIMCE results and socioeconomic and academic segregation in schools

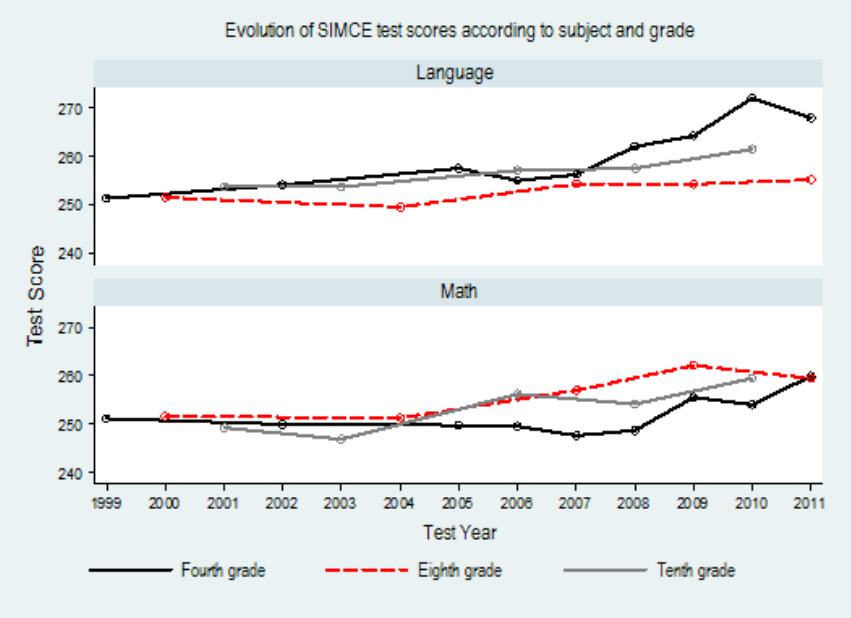
The SIMCE census tests gather information on the performance of students in different areas of the Chilean curriculum. Until 2005, the tests alternated between grades four, eight and ten. Since 2006, the fourth grade has been evaluated on an annual basis and the eighth and tenth grades on alternating years. In addition to curriculum-related tests, SIMCE also collects data on teachers, students, and parents or legal guardians. In this study, we use the language and math test results of fourth, eighth and tenth grade students from 1999 to 2011.

The data generated by SIMCE shows that the scores of Chilean students have increased steadily over the past several years. Figure 1 shows the trends in reading and math score results since 1999. The most pronounced change is in fourth grade reading. While in 1999 the average score of a fourth grade student in language was 251 points, in 2011 the average rose to 268, an increase of almost 0.4 standard deviation units[2]. The improvement was less notable in the eighth grade, from 251 to 255 points, while in the tenth grade, the increase between 2001 and 2010 was from 253 to 261.5 points.

With respect to math scores, positive changes were also observed although to a lesser degree than those in language scores. Fourth grade scores increased from 251 to 260 points (equivalent to 0.2 standard deviations) between 1999 and 2011. The eighth grade saw an increase from 251 to 259 points between 2000 and 2011 and the tenth grade rose from 249 to 259 points between 2001 and 2010 (for more details on these trends, see Appendix 1). These data indicate that increases in both subjects were more significant in the second half of the last decade and more pronounced in the fourth grade.

[2] SIMCE test scores are standardized on a scale with a mean set at 250 points and a standard deviation of 50. For fourth grade tests this scale was first used in 1999, while for eighth and tenth grade tests it was used in 2000 and 1998, respectively.

Figure 1. Fourth, eighth and tenth grade SIMCE test results, 1999-2011



Source: Compiled by the authors based on SIMCE data

Education systems can either be inclusive or segregated according to their ability to distribute students with similar characteristics (socioeconomic status, academic level, ethnicity, etc.) in a homogenous manner among different schools or in different geographical regions. This analysis focuses primarily on segregation by student socioeconomic status and test scores among the various schools. In this section, we follow the approach to segregation used by Willms 2010, and also employed in the equity analyses of the PISA 2009 (OECD, 2010) and in Education at a Glance (OECD, 2011)[3]. An education system is considered to be highly segregated when there is a strong differentiation between schools due to a high concentration of students of a particular socioeconomic status (socioeconomic segregation) or a certain level of test scores (academic segregation). School segregation in Chile has recently been studied by several authors using different conceptual approaches and methods than the ones used here, but with substantive conclusions similar to those presented in this section (see Valenzuela et. al., 2010; Martinic and Elacqua, 2010; and Mineduc, 2012a).

To measure segregation, we used the Intra-class Correlation Index (ICC) which is calculated as the variability of the indicator of interest (socioeconomic status or test score) attributable to the

[3] It should be noted that the PISA 2009 makes reference to the Social Inclusion Index, which is considered the complement to the ICC shown here and is calculated as the value of one (1) minus the estimated value of the ICC.

school divided by the total variability of the indicator (see Appendix 2)[4]. The ICC can be interpreted as the probability that a randomly selected pair of students from a given school will have a similar socioeconomic status or test results (Hox, 2010). Therefore, ICC levels close to one suggest a high probability that students in the same school will have similar academic or socioeconomic levels, indicating a high level of segregation. In contrast, ICC levels close to zero show that in these schools students are from a wide range of socioeconomic backgrounds or academic levels, indicating a low degree of segregation.

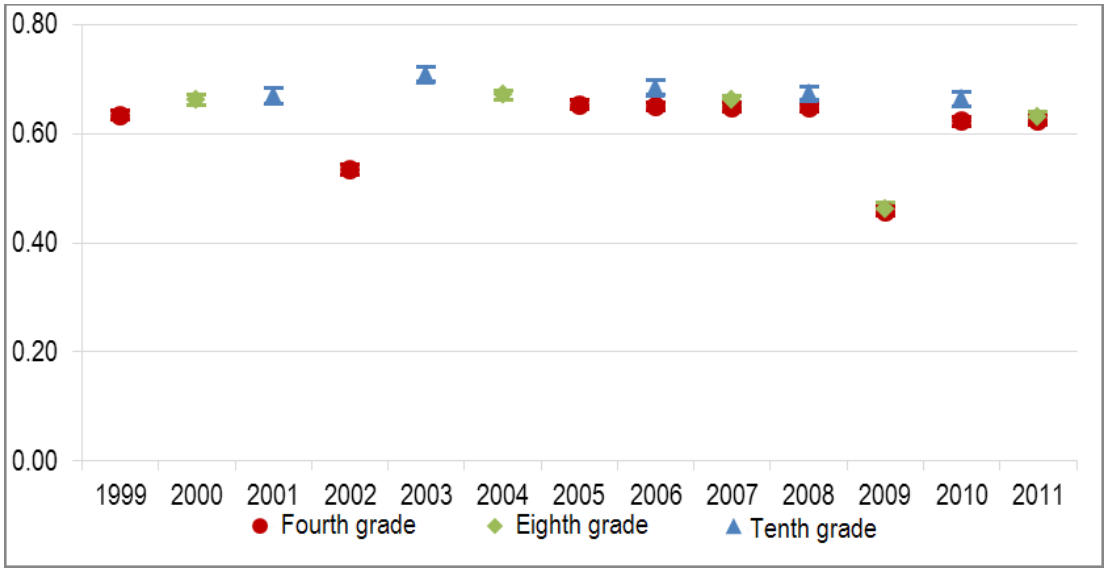
Social segregation. According to the results, there is a high degree of social segregation in Chilean primary and secondary schools and this has remained consistent throughout the period analyzed: the ICC for student socioeconomic status reaches values above 0.60 (Figure 2). This indicates that the probability of students of a particular socioeconomic status being in the same school as students of a similar socioeconomic background is greater than 60%. This demonstrates that the most disadvantaged students attend schools with peers in similar situations and vice versa[5]. The level of social segregation in Chilean schools is high when compared to similar estimates for schools in other OECD countries, in the context of PISA tests, which indicate a social segregation ICC of approximately 0.25 for 2009 (OECD 2011)[6].

[4] The socioeconomic status or SES is a summary measure computed from the total reported family income per household and the highest education level of each of the student's parents. This data is gathered on all tests through a questionnaire given to parents.

[5] The 2009 data exhibits what appears to be an error in the answers to questions regarding the education level of parents. In the year in question, a much greater number of parents report having 0 or 1 years of education compared to earlier and later years. Given that this variable is part of the SES index used in the analyses, the high number of responses from parents with 0 and 1 years of education leads to a greater number of students being classified as having a low SES, resulting in a very low ICC value. Therefore, the 2009 data must be treated with caution.

[6] The social segregation ICC for Chile based on the 2009 PISA is 0.51, the highest of the OECD countries. Estimates based on SIMCE data for the tenth grade, which is the grade level comparable with PISA, are even higher, as shown in Figure 2.

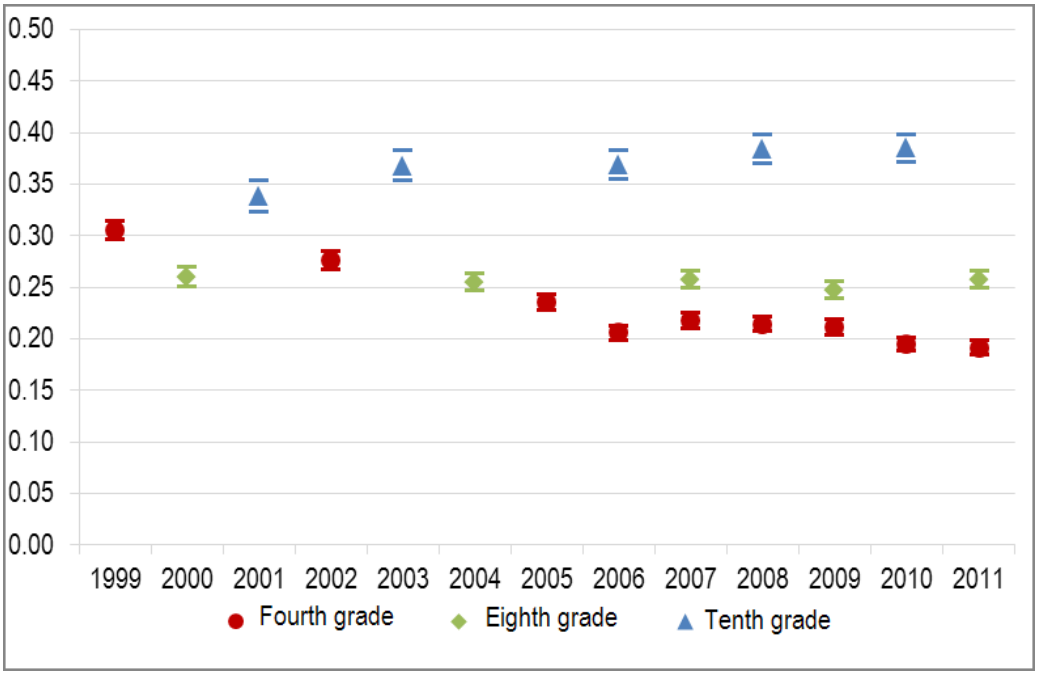
Figure 2. Evolution of the Intra-class Correlation Index for SES



Note: Symbols represent the ICC value for each grade. Parallel lines indicate the upper and lower limits of the ICC confidence interval for a 95% confidence level.

Academic segregation. Academic ICC estimates for the various tests reveal differentiated trends over the period analyzed (see Figure 3 and Appendices 3 and 4). On fourth grade language tests, there was a statistically significant reduction from 0.30 in 1999 to 0.19 in 2011, while in math the ICC oscillated slightly around 0.28. There were no significant changes in eighth grade language or math. In contrast, the tenth grade saw a modest but significant increase in academic segregation between 2001 and 2010; the ICC rose from 0.33 to 0.39 in language and 0.45 to 0.49 in math. These results suggest that while academic segregation is relatively low in primary schools, as students advance through their schooling a process of "skimming" takes place, evident at the high school level, whereby schools tend to select students based on academic achievement. The highest ranking students are grouped with other high achievers, and vice versa. These results are consistent with and very similar to those presented by Manzi, Strasser, San Martín and Contreras (2008).

Figure 3. Evolution of the Intra-class Correlation Index for Language Test Scores



Note: Symbols represent the ICC value for each grade. Parallel lines indicate the upper and lower limits of the ICC confidence interval for a 95% confidence level.

2. Evolution of differences in test scores between and within schools and their relationship to student SES

After analyzing the variability of test scores and socioeconomic status separately in order to describe the segregation, in this section we analyze how much of the variability in academic achievement is associated with the socioeconomic characteristics of the students and of the schools they attend.

The association between student socioeconomic status and test scores can be divided into two parts, one related to the characteristics of the students and the other to the characteristics of the schools. To do so, we estimate a multilevel model for each year, grade and subject that simultaneously controls for the socioeconomic status of the students and that of the schools. The latter is estimated based on the average aggregate value of the students in each school. By breaking down this relationship, we can estimate the magnitude of variability in student outcomes explained by the differences within schools (intra-school variability) and the differences between schools (inter-school variability). Test results for Chile since 1999 are presented in Table 1. The intercept of the scores, that is the average score in a school with a student body of average socioeconomic status, increased for all grades, but to a much greater extent in fourth grade language, which is consistent with the findings presented in the previous section. The within-school variability of the relationship between student SES and test scores is

low and remains consistent throughout the period analyzed, with the exception of fourth grade language which shows a decrease from 3.4% to 1.4% in the explained variance.

Table 1. Breakdown of the association between student socioeconomic status and test scores (within- and between-school variability)

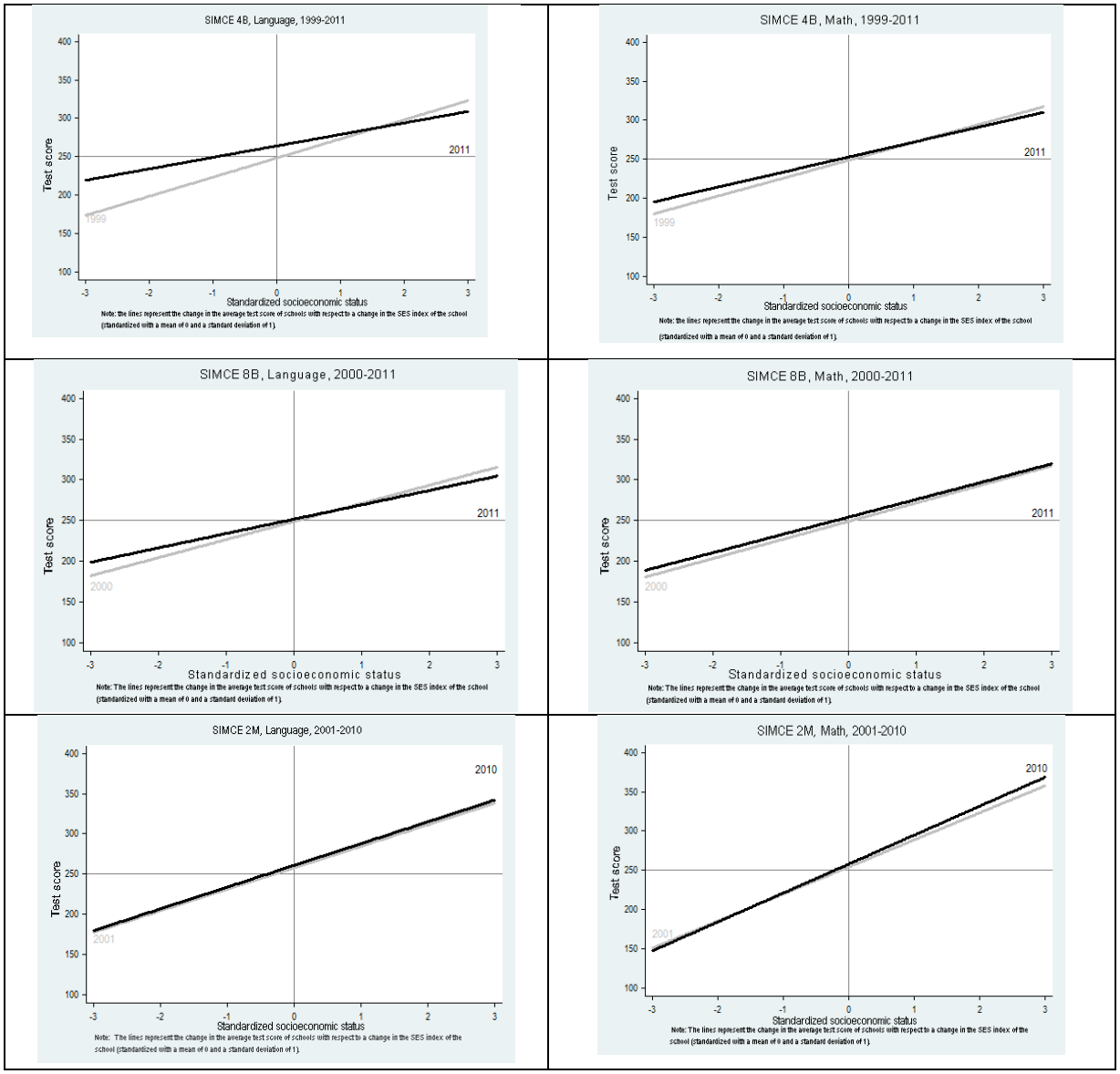
	Language					Math				
	Intercept	Within-School Coefficient	Percentage of variance explained	Between-School Coefficient	Percentage of variance explained	Intercept	Within-School Coefficient	Percentage of variance explained	Between-School Coefficient	Percentage of variance explained
Fourth grade										
1999	248.4	12.4**	3.4	24.9**	68.7	248.8	11.7**	2.9	22.8**	65.7
2002	249.8	11.5**	3.1	25.2**	64.4	245.0	11.7**	3.2	25.6**	64.5
2005	253.3	13.9**	3.1	22.1**	62.0	244.6	14.4**	3.1	23.7**	60.8
2006	252.3	13.1**	2.5	19.3**	53.5	243.7	14.3**	3.1	23.9**	58.1
2007	253.0	12.5**	2.3	19.5**	52.6	241.8	13.7**	2.8	23.8**	55.0
2008	257.6	10.9**	1.7	19.1**	52.3	241.7	12.6**	2.5	23.9**	56.2
2009	257.5	7.6**	1.1	19.0**	50.2	245.8	8.7**	1.6	23.7**	52.6
2010	267.6	10.1**	1.6	16.4**	46.6	246.5	12.2**	2.5	22.2**	51.1
2011	264.2	9.3**	1.4	14.9**	39.9	252.9	10.5**	2.0	19.1**	42.3
Eighth grade										
2000	249.0	10.0**	2.1	22.2**	65.1	249.0	9.6**	2.0	22.7**	61.5
2004	248.1	12.0**	2.7	22.9**	65.3	249.8	11.1**	2.6	23.8**	64.1
2007	250.4	10.7**	2.1	21.8**	61.0	252.4	10.6**	2.2	24.3**	64.1
2009	249.1	7.1**	1.3	19.9**	50.8	255.1	7.6**	1.7	25.0**	60.3
2011	251.8	8.9**	1.5	17.6**	41.5	254.3	9.0**	1.8	21.8**	54.9
Tenth grade										
2001	258.0	7.6**	1.2	26.7**	68.8	254.4	7.8**	1.3	34.4**	73.4
2003	257.6	9.4**	2.1	26.6**	70.2	253.3	9.1**	1.6	35.8**	65.7
2006	258.0	7.4**	1.2	27.1**	66.6	256.9	8.2**	1.1	37.1**	62.2
2008	257.3	7.5**	1.3	27.1**	66.9	253.6	7.6**	1.1	37.0**	63.7
2010	261.0	7.2**	1.2	27.0**	65.7	258.1	7.9**	1.2	36.8**	64.6

Note: Significance levels ** p<0.01, * p<0.05, + p<0.10
See Appendix 2 (methodology) for details on the multilevel model used for the estimates in this section.

In contrast with the low degree of within-school variability throughout the period analyzed, there are significant changes in the between-school variability. In fourth grade language, the variation in scores related to the average SES of schools dropped from 24.9 points in 1999 to 14.9 in 2011 (per standard deviation of the SES school average), which represents a decrease in the explained variance of 68.7% to 39.9%. Fourth grade math saw a smaller but equally significant drop, from 65.8% to 42.3%. A similar trend was observed in the eighth grade: from 65.1% to 41.5% in language and 65.1% to 54.9% in math. In the tenth grade, however, within-school variability appears not to have changed since the beginning of the millennium. These data indicate an improvement in terms of educational equity in the fourth and eighth grades, insofar as the relationship between the socioeconomic background of students is in lesser proportion to their language and math scores. In contrast, at the high school level there remains a strong relationship between student socioeconomic status and academic outcomes. Improvements in educational

equity at the primary school level are greater in language than in math, suggesting the need for future studies to explore the reasons behind these differences. Figure 4 illustrates this, comparing the first and last years of the period analyzed.

Figure 4: Evolution of the relationship between socioeconomic status and test results



The above analysis indicates that during the first decade of the 21st century, significant improvements were made in Chilean primary school education in terms of educational quality, along with a considerable, albeit selective, increase in equity. The high degree of existing inequities in primary school education begins to drop, to a greater extent and most significantly, in the fourth grade. This is also observed in the eighth grade, although the change is less pronounced. Students from the poorest families saw a reduction in the learning gap with respect

to those from the wealthiest families in both subjects, although improvements were more significant in language than in math. The explanation of these improvements exceeds the scope of the current study. Further research should be done to examine the reasons behind these improvements as well as the basis for the difference between advances made in language and math.

3. Evolution of the gaps by socioeconomic status in student test scores

In the previous section, we analyzed the evolution of the relationship between student test scores and family socioeconomic status over time. We found that advances have been made in educational quality and equity at the primary school level, but not in secondary schools. Our analysis describes the trend in this relationship assuming that the distribution of the socioeconomic status of student households has remained relatively stable over time. However, there was an improvement in income distribution in Chile between 1998-2012 and during this period the Gini coefficient fell from 0.57 to 0.52 (Ministerio de Desarrollo Social, 2012 and 2013). This demands an approach where SES indexes are comparable throughout the entire period analyzed.

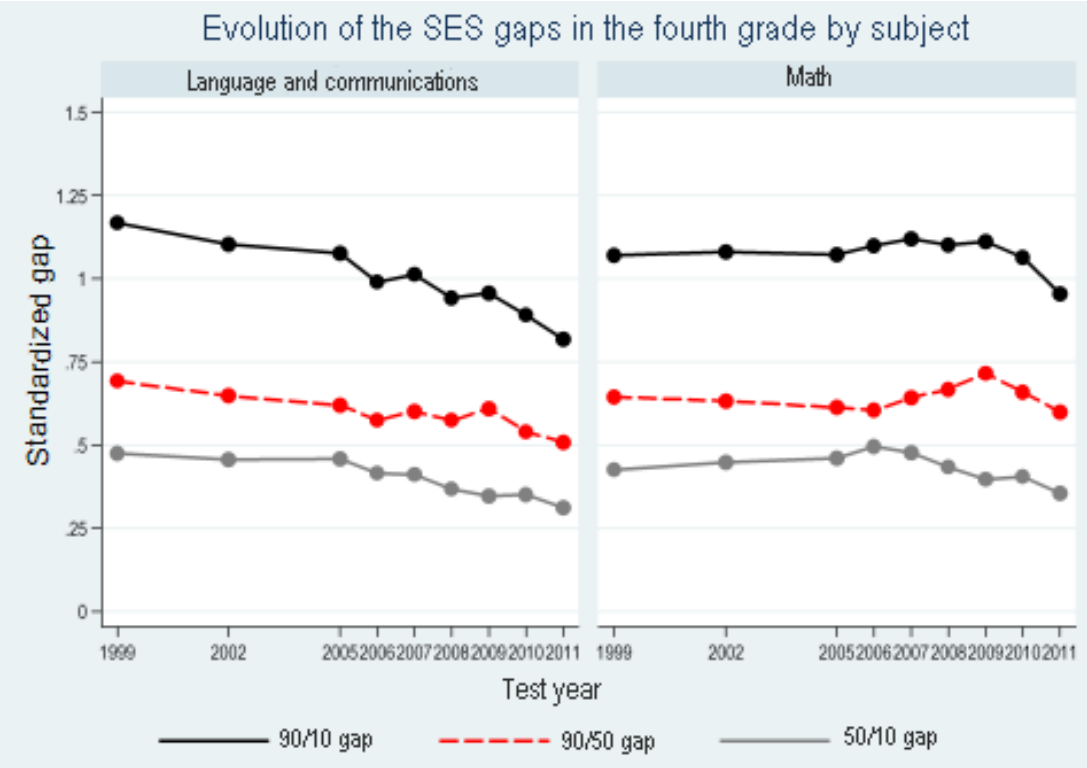
The methodology developed by Reardon (2011) to analyze the relative achievement gaps between low-income and high-income students in the United States facilitates the comparison over time of the relationship between the socioeconomic status of families and academic test scores by using the variations in standardized achievement gaps controlled by socioeconomic status (that is, the difference in test scores between students located along different points of the socioeconomic distribution). Focusing on the comparison between gaps attenuates potential problems generated by changes in the SES distribution, or its component parts, over time. In this section, we will analyze the trends these gaps have followed from 1999-2011.

We initially estimated the gap using the 90th and 10th percentiles of the student SES index. These percentiles represent the students located at both extremes of the distribution and allow us to discuss the degree to which the differences between the social groups at both extremes have changed (increased or decreased). Since it is possible that the gaps at other points along the distribution reveal different activity not reflected by the gap between the 90th and 10th percentiles, we also examined the relationship between other significant points along the distribution. Specifically, we looked at the gaps between the 90th and 50th percentiles and between the 50th and 10th percentiles. These two additional estimates allow us to verify whether the gap observed between the extremes is replicated with respect to the midpoint of the distribution; in other words, whether the relationship is constant between the students with greater resources in relation to those with average resources and, in turn, with those of lower socioeconomic status.

The discussion of the results will center on the tests given to fourth grade students since in this group we observed increased variation in score tests. The results of the gaps in the eighth and tenth grades also suggested a decline, but at a slower pace (see Appendix 5). Figure 5 shows that for language, the gap in the academic results of students in the 90th percentile of the SES index with respect to those in the 10th percentile fell by 30%. In 1999, the gap was 1.17 standard deviations, while in 2011, it was 0.82. The gap also decreased in math, but to a lesser degree (11%) over the same period (see Appendix 5).

The estimates of other gaps on the distribution of the SES index–the 90th and 50th percentile gap and the 90th and 10th percentile gap–suggest a similar trend. They also experienced a decline over the same period, but with several differences. The 90/50 percentile gap decreased, but the proportion of the decrease between the beginning and end of the period is smaller compared to the decrease in the 90/10 gap (27% and 7% in language and math, respectively). In contrast, the decrease in the gap between the 50th and 10th percentiles is larger, relatively speaking; the gaps were reduced by 35% and 17% between 1999 and 2011 on the language and math tests, respectively. This suggests that the students in the poorest decile saw relatively greater gains in quality compared to the rest of the SES deciles.

Figure 5: Evolution of the achievement gap by student SES, fourth grade, for selected percentiles

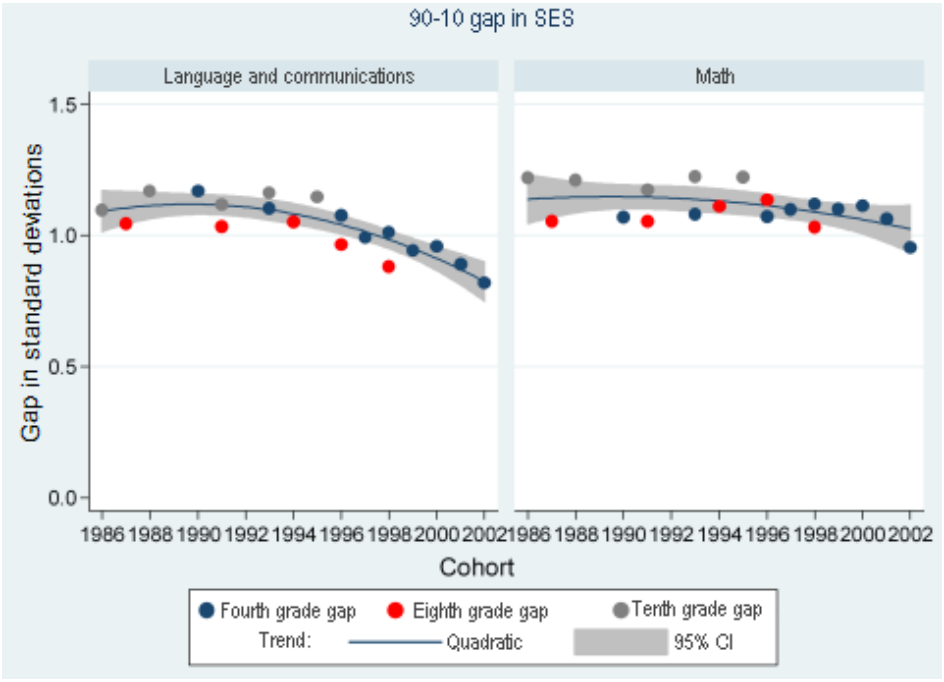


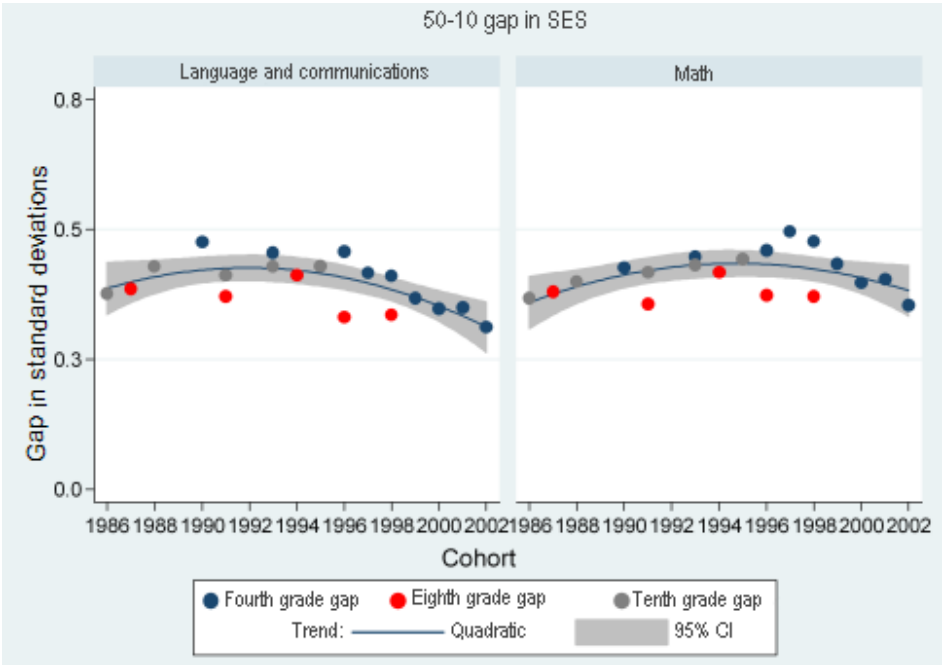
Note: The scores of each test are standardized by year with a mean set at 0 and standard deviation of 1. The gap in scores is the difference in standardized scores between two points on the student household income distribution.

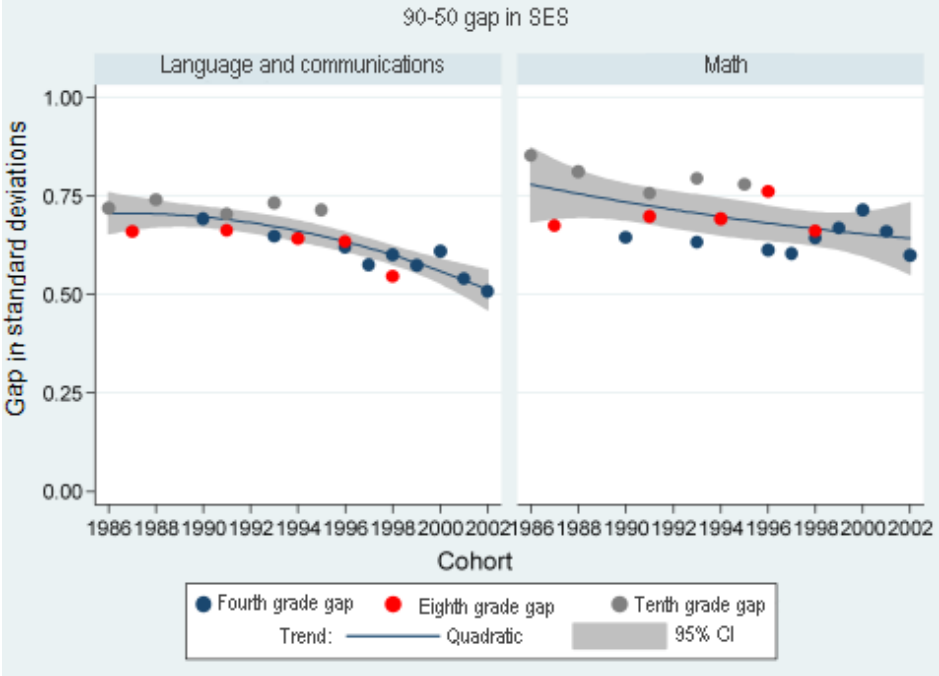
Alternately, the achievement gaps by socioeconomic group can be analyzed according to student birth cohort instead of test year. This will give us an idea of whether or not the educational opportunities (in terms of quality) available to each new cohort of children are more equitable, independent of the grade in which they take the test. In Figure 6, we present the trends in achievement gaps for different SES percentiles (90/10, 90/50 and 50/10) for the cohorts of students evaluated[7]. Plotting the data in this manner also allows us to improve the robustness of the description of these trends, to the extent that we can incorporate more points over time, generating a more stable evolution of the trend.

[7] Since we do not have the exact age of students at the time of taking the test, we used a loose definition of cohort, assuming that all the students evaluated were born in the same year.

Figure 6. Trends in the achievement gap by birth cohort, 1986-2002







The results of this analysis confirm previous findings: the gaps decrease over time. The gap between the 90th and 10th percentiles on language tests has fallen at a steady rate. Therefore, we can see that the learning gaps at different grade levels for students born in the 1980s were greater than for those in more recent cohorts. Additionally, the reduction over time has been progressive regardless of the grade level evaluated. The gaps in math tests have decreased progressively, although at a much slower pace than in language. With respect to language tests, the 90/10 gap followed a reduction trend of 0.025 standard deviations per year and a 1% significance level. While on the math tests, the reduction was 0.01 per year, statistically significant at 1%. The results of the gap estimates for the other ratios (90/50 and 50/10) with respect to language tests also show a declining trend which, although of a lesser magnitude, has a similar significance. With respect to math, we find decreases, statistically significant at 1%, for the 90/50 gap but not for the 50/10 gap (see Appendix 6). The trends observed using the SES are reproduced when family income is used to estimate the gaps (see Appendices 7 and 8).

Final Remarks

The various analyses exhibited in this study reveal remarkable progress in the Chilean education system for the 1999-2011 period, in both educational quality and equity. The national test results reveal increasing gains in quality, which are greater in primary than in secondary school and in language over math. These improvements, however, do not necessarily translate into a reversal

of the socioeconomic segregation of Chilean schools which continues to remain high and which rises as students advance through their school career.

This document presents several different learning equity indicators and estimates which produce outcomes that are consistent with one another and confirm the findings reported by the various measurements of this study. We analyzed the evolution in the relationship between academic outcomes and SES within and between schools. While within schools that relationship remained low and stable throughout the period analyzed, in contrast, the between-school relationship between scores and SES, which has always been high, has declined remarkably, especially at the primary school level. These results indicate that despite the extended levels of social segregation previously mentioned, over the last several years the differences in the average performance of schools attended by low-income students with respect to those of a better socioeconomic status, has decreased. This also confirms that, on the one hand, schools continue to play an important role in contributing to the potential reversion of social disadvantages and, on the other, that the persistence of social segregation in schools is not incompatible with improved academic achievement among the most disadvantaged socioeconomic groups.

Likewise, to verify whether the trends in the differences between schools held steady, we used an alternative approach to investigate changes in achievement gaps between groups of students of different socioeconomic backgrounds. This analysis confirmed a decrease in the gaps that existed during the period analyzed which suggests that each new cohort born after 1988 has encountered, at least in primary school, smaller learning gaps with respect to their socioeconomic status. The results of the various analyses indicate that the poorest segment of students saw relatively greater improvements in quality compared to other segments of the student population. This demonstrates significant, though insufficient, improvements in educational equity in Chile.

The results of the study suggest that the sustained efforts of Chilean society to improve educational quality and equity are on the right path. As indicated in the introduction, one of the actions supported by Chile in recent years is a change in the funding formula for schools. Since 2008, schools receive an additional allocation for socioeconomically disadvantaged students. The new design is expected to have a positive influence on equity levels in the local education system. In this way, the hope is to achieve the desired objective of reducing, in addition to academic achievement gaps, school segregation (preliminary assessments indicating positive effects can be seen in Murnane, Page and Vegas, 2010; Mineduc, 2012b). Future analysis will confirm whether or not the impulse behind the Preferential School Subsidy will finally be met with empirical correlation which will help guide future actions, not only in this country but in other education systems with similar challenges.

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Appendix 1. Mean and standard deviation of test scores and of the socioeconomic status index, and initial sample size and analytics by grade and test year

Panel A: Fourth grade

	Initial Sample									Analytical Sample								
	Language Score			Math Score			SES Index			Language Score			Math Score			SES Index		
	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)
1999	250.1	50.0	281039	250.0	50.0	281468	0.0	1.0	250380	251.4	49.7	240234	251.2	49.8	240234	0.0	1.0	240234
2002	251.4	53.7	251408	247.4	54.0	251182	0.0	1.0	220144	254.1	53.1	203169	250.0	53.5	203169	0.0	1.0	203169
2005	255.4	53.3	252695	247.5	55.3	252481	0.0	1.0	214354	257.6	52.9	209527	249.7	55.0	209527	0.0	1.0	209527
2006	253.3	53.9	248130	247.7	55.9	248061	0.0	1.0	220724	254.9	53.6	215735	249.5	55.4	215735	0.0	1.0	215735
2007	254.5	53.6	241498	245.8	56.4	241809	0.0	1.0	214800	256.2	53.4	169793	247.6	56.2	169793	0.0	1.0	169793
2008	260.5	53.7	236495	247.1	55.0	236849	0.0	1.0	212841	262.0	53.5	206222	248.7	54.9	206222	0.0	1.0	206222
2009	261.9	53.4	219753	252.8	55.1	219643	0.0	1.0	170521	264.3	53.1	163015	255.5	54.9	163015	0.0	1.0	163015
2010	270.7	50.3	230160	252.7	53.6	230119	0.0	1.0	208468	272.0	50.0	199721	254.1	53.4	199721	0.0	1.0	199721
2011	266.8	50.4	216748	258.7	50.6	216506	0.0	1.0	200012	268.0	50.1	188255	259.9	50.4	188255	0.0	1.0	188255

Panel B: Eighth grade

	Initial Sample									Analytical Sample								
	Language Score			Math Score			SES Index			Language Score			Math Score			SES Index		
	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)
2000	250.0	50.0	245206	250.0	50.0	246418	0.0	1.0	162102	251.6	49.9	160746	251.6	49.7	160746	0.0	1.0	160746
2004	251.4	52.1	275547	253.1	50.2	276365	0.0	1.0	175727	249.6	51.7	172718	251.3	49.9	172718	0.0	1.0	172718
2007	252.9	51.1	255439	255.6	51.6	256109	0.0	1.0	217857	254.3	51.0	212866	257.0	51.6	212866	0.0	1.0	212866
2009	251.8	51.1	227688	259.6	51.9	227993	0.0	1.0	168563	254.2	50.9	162624	262.1	51.9	162624	0.0	1.0	162624
2011	253.8	50.3	221383	258.6	49.0	221189	0.0	1.0	186776	255.2	49.8	179649	259.4	48.8	179649	0.0	1.0	179649

Panel C: Tenth grade

	Initial Sample									Analytical Sample								
	Language Score			Math Score			SES Index			Language Score			Math Score			SES Index		
	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)	Mean	Std. Dev.	N (students)
2001	251.3	52.2	192804	246.6	55.6	192655	0.0	1.0	134023	253.7	52.7	134023	249.3	56.6	134023	0.0	1.0	134023
2003	253.0	50.0	238760	245.8	60.0	238898	0.0	1.0	180150	253.7	50.1	177549	246.9	60.1	177549	0.0	1.0	177549
2006	254.3	51.9	243914	252.0	65.0	243834	0.0	1.0	187773	257.1	51.9	183087	256.2	65.1	183087	0.0	1.0	183087
2008	254.8	50.6	228506	250.0	62.3	228661	0.0	1.0	189050	257.6	50.7	181948	254.1	62.5	181948	0.0	1.0	181948
2010	259.0	51.1	227207	255.9	62.0	227728	0.0	1.0	190165	261.5	51.0	183965	259.5	62.0	183965	0.0	1.0	183965

Note: The values in this Appendix differ slightly from the intercepts in Table 1 because the null multilevel model used for this table adjusts the coefficients based on school sample size (which only includes cases with complete data for all the variables analyzed

Appendix 2
Methodological Appendix

Regarding the data used

The analyses presented in this report used the test score databases from the Chilean Ministry of Education's quality measurement system or SIMCE. We used the databases for the tests given to fourth, eighth and tenth grade students between 1999 and 2011. In addition to this, we also used data from the surveys completed by students' parents. These surveys contain data that was used to construct an index of the socioeconomic status of students' families (father's education level, mother's education level and household income). The databases were provided by the Centro de Estudios of the Chilean Ministry of Education.

With the objective of retaining a more extensive data series which would be comparable over time, the analyses presented here focus on the language and math tests that were given consistently throughout the period analyzed. For all estimates, we used only those observations with valid data (without null or omitted data) for scores on the respective tests. Additionally, we retained those observations with complete data for the three variables of socioeconomic status index.

The scores and the sample size of students and analytics (the sample retained for the analyses) for each test and year are shown in Appendix 1. In nearly all cases, the samples retained by grade and year show a difference in average scores between 0.8 and 4.0 points above the national average estimated using the initial samples. The only exception are the eighth grade test scores from 2004 with an average two points below the average of the initial sample.

Estimation of the intra-class correlation index (ICC) for estimating academic and social segregation.

The intra-class correlation index (ICC) is a measurement that allows us to estimate the level of homogeneity existing between the units that make up the unit that contains them. In our case, the ICC indicates the degree of similarity among students that attend the same school. The degree of similarity can be estimated for any feature of interest. In this report we focused on two features: the similarity of students' socioeconomic status and their SIMCE test results, specifically language and math.

The estimated ICC is calculated using a null multilevel model with two levels, students and schools. This enables the separation of the total variance into two parts, one corresponding to the variance attributable to the schools and the other, to the students. The ICC value is derived by estimating the ratio of variance between schools with respect to the total variance.

The ICC is calculated as follows:

$$Y_{ij} = \gamma_{00} + u_{0j} + r_{ij}$$

Where:

Y_{ij} : value of the variable of interest of student i in school j

γ_{00} : overall intercept (overall average, performance for all schools)

r_{ij} : residual of student i in school j

u_{0j} : skewness (residual) of the average school performance j with respect to the overall intercept

Assuming that the variance of the residuals of the student, Var(r_{ij}), corresponds to the within-school variance and the variance of the variations of the schools with respect to the grand mean, Var(u_{0j}), is the variance between schools, the total variance can be written as:

$$\text{Var}(Y_{ij}) = \text{Var}(u_{0j}) + \text{Var}(r_{ij}) = \tau_{00} + \sigma^2$$

Where:

τ_{00} : Within-school variance

σ^2 : Between-school variance

Finally, the ICC is expressed as:

$$\text{ICC} = \tau_{00} / (\tau_{00} + \sigma^2)$$

Decomposition of the relationship between the socioeconomic status of students' families and SIMCE test score results.

In a multilevel model, we can decompose the relationship between the overall socioeconomic gradient and test scores. In this way, the gradient can be separated into two parts, one related to the socioeconomic traits of students, called the within-school relationship, and the other associated with the socioeconomic composition of the schools, called the between-school relationship. The decomposition is done by estimating a multilevel model where the dependent variable is the score of each student and the socioeconomic index of the student and the socioeconomic status of the school the student attends are included as explanatory variables. This last variable is an aggregate variable that is specified as the average SES of all students attending the same school as each student.

The model is expressed as follows:

$$Y_{ij} = \beta_{0j} + \beta_{1j}(X^*_{ij}) + r_{ij}$$

Where:

$$\beta_{0j} = Y_{00} + Y_{01}(\overline{X}^{*}_{\bullet j}) + U_{0j}$$
$$\beta_{1j} = Y_{10} + U_{1j}$$

The equation can be re-expressed as:

$$Y_{ij} = Y_{00} + Y_{10}(X^{*}_{ij}) + Y_{01}(\overline{X}^{*}_{\bullet j}) + r_{ij} + U_{0j} + U_{1j}$$

The literature on multilevel models recommends centering the variable that represents the student's socioeconomic status (X_{ij}) to facilitate the interpretation of the results. The group level used for centering affects the interpretation of the estimated outcomes. To estimate the within- and between-school relationship, the socioeconomic status index of each student is centered on the school mean ($X^{*}_{ij} = X_{ij} - \bar{X}_{\bullet j}$). In this way, the coefficient associated with the student's socioeconomic status (Y_{10}) is interpreted as the part that corresponds to the differences within the school, or intra-school effect, while the coefficient associated with the average socioeconomic status of the school (Y_{01}), as that part of the difference explained by the effect between schools.

Methodology for the analysis of gaps using household income

Reardon's main assumption is that behind categorized income, there is a latent variable with a continuous distribution. Based on this assumption, the proportion of the cumulative population in each of the intervals can be used to infer the value of the latent variable for each. Then, said value enters a regression function where we model the relationship with the value of the average test score associated with each category of family income and the value of the latent variable for each income interval. The coefficients estimated in the regression are used to estimate the test scores achieved at different points on the income distribution and thus estimate the learning gaps. As in the initial example, the gap can be retrieved for the 90th and 10th percentiles (and others). As is commonly done, the outcomes of the analysis of the gaps are expressed in standard deviations with respect to the average score, rather than using the original scale[8].

The general formulation of the model is as follows (strictly based on the one developed by Reardon, 2011): Suppose that there is a continuous latent variable called *theta* (θ) that measures a familiar feature such as total family income, for example. Said variable is distributed according to uniform density function phi (theta) = Φ (θ) and with a cumulative density function in the population Phi (theta) = Φ (θ). What we observe is a crude measurement of (θ), that is, a measurement using a reduced number of discrete categories instead of a continuous measurement. Thus, what we observe is X, a discrete measurement of θ, where X = $\varepsilon\{1,2,\ldots,K\}$.

[8] Reardon also recommends that when dealing with tests from different studies, the reliability estimates for each test should be used to adjust student test scores and reduce possible measurement bias. These estimates were not available at the time. However, given that the SIMCE test has maintained the same scale from year to year, we believe that the reliability levels of the test are similar.

Now, let's assume that c_k is the proportion of the population with values of θ in the category k or below (and where $c_0=0$, $c_k=1$). Therefore, $X = k$ if $\Phi^{-1}(c_{k-1}) < \theta < \Phi^{-1}(c_k)$.

We want to establish the relationship between some measurement of the student's academic achievement, indicated by Y and θ. That means that if the relationship between Y and θ can be described by the function $Y = f(\theta) + \varepsilon$, where $E(\varepsilon \mid \theta) = 0$, we must estimate the function f. However, since we are unable to observe θ, we must infer the function f from the average observed values of Y of each category of X. Thus, the average value of θ within each ordinal category k can be expressed as follows:

$$\bar{\theta}_k = \frac{c_k + c_{k-1}}{2}$$

The average value of academic achievement Y within each ordinal category k is expressed as follows:

$$\bar{Y}_k = \frac{\int_{\Phi^{-1}(c_{k-1})}^{\Phi^{-1}(c_k)} f(x)\,\Phi(x)dx}{(c_k) - (c_{k-1})}$$

Assuming that f can be approximated by a cubic polynomial function as:

$$Y = f(\theta) + \epsilon = a + b\theta + c\theta^2 + d\theta^3 + \epsilon, \quad E(\epsilon|\theta) = 0$$

If $\phi(\theta)$ represents a uniform density function, then the average value of Y in each category k can be derived and expressed as

$$\bar{Y}_k = a + b\bar{\theta}_k + c\left(\bar{\theta}_k^2 + \frac{(c_k - c_{k-1})^2}{12}\right) + d\left(\bar{\theta}_k^3 + \frac{(c_k - c_{k-1})^2}{4}\right)$$

Finally, we can calculate the average value of theta for each interval, $\bar{\theta}_k$, using the formula developed above and then estimate the value of a, b, c, and d using a regression where we estimate the average score for each interval, $\bar{Y}_k$, using $\bar{\theta}_k$ and their quadratic and cubic terms. Thus, the values $\hat{a}, \hat{b}, \hat{c}$ and $\hat{d}$ describe the estimated relationship between θ and Y.

This method allows us to estimate the relationship between the scores observed on the SIMCE test and the measurement we have of socioeconomic status (household income). To estimate the academic achievement gap by income between one student whose family is in the 90th income percentile and another in the 10th percentile, the 90/10 gap, we use the following general formula:

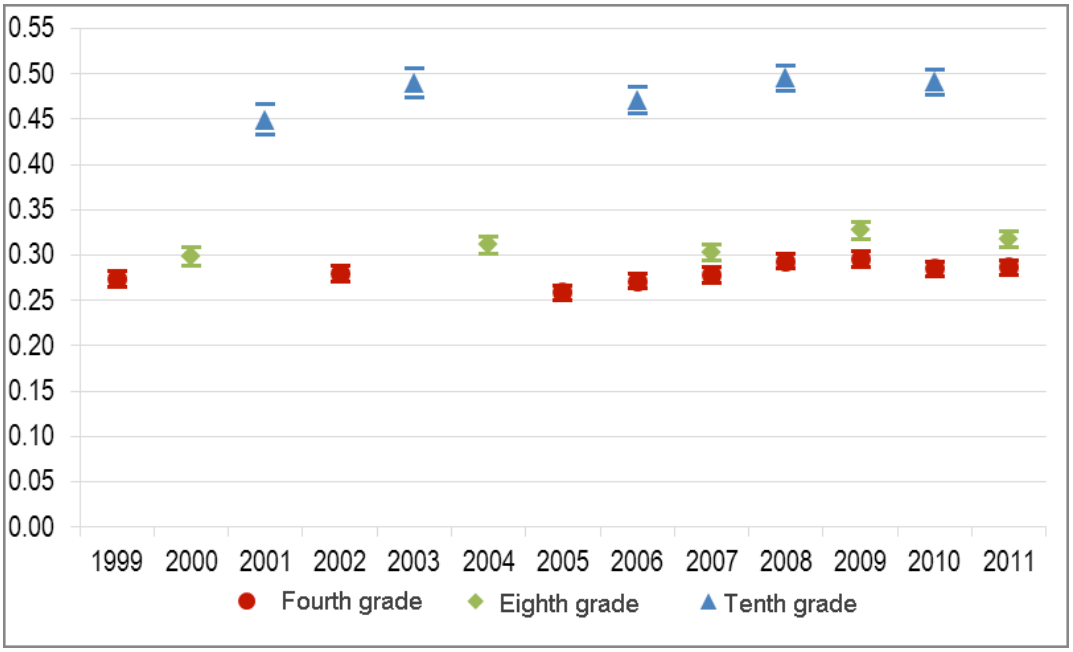
$$\delta^{90/10} = \left[\hat{Y}|\theta = .9\right] - \left[\hat{Y}|\theta = .1\right] = .8\hat{b} + .8\hat{c} + .728\hat{d}$$

Then we repeat the estimate of the gaps for each of the tests and grades we have available data for. The result is a general overview of the evolution of trends in learning gaps where each test offers a snapshot of the relationship between the household economic status of students and their test results at a given moment in time.

Appendix 3: Evolution of the Intra-class Correlation Index of SES

	Fourth grade			Eighth grade			Tenth grade		
	Fourth grade	Lower Limit	Upper Limit	Eight grade	Lower Limit	Upper Limit	Tenth grade	Lower Limit	Upper Limit
1999	0.634	0.625	0.643						
2000				0.66	0.652	0.672			
2001							0.670	0.655	0.685
2002	0.534	0.524	0.543						
2003							0.709	0.696	0.722
2004				0.671	0.662	0.680			
2005	0.653	0.645	0.661						
2006	0.650	0.642	0.658				0.685	0.673	0.697
2007	0.648	0.639	0.657	0.662	0.653	0.670			
2008	0.648	0.640	0.656				0.675	0.662	0.687
2009	0.458	0.449	0.467	0.463	0.453	0.473			
2010	0.623	0.615	0.631				0.664	0.651	0.676
2011	0.624	0.616	0.632	0.631	0.622	0.640			

Appendix 4: Evolution of the academic segregation in math



Note: Symbols represent the ICC value for each grade. Parallel lines indicate the upper and lower limits of the ICC confidence interval for a 95% confidence level.

Appendix 4 (continuation)

Panel A: Math Test

	Fourth grade			Eighth grade			Tenth grade		
	ICC	Lower Limit	Upper Limit	ICC	Lower Limit	Upper Limit	ICC	Lower Limit	Upper Limit
1999	0.274	0.265	0.283						
2000				0.298	0.288	0.309			
2001							0.450	0.433	0.466
2002	0.279	0.271	0.288						
2003							0.490	0.475	0.506
2004				0.311	0.302	0.320			
2005	0.258	0.251	0.266						
2006	0.271	0.263	0.279				0.471	0.456	0.486
2007	0.279	0.270	0.287	0.303	0.294	0.312			
2008	0.293	0.285	0.301				0.495	0.481	0.510
2009	0.296	0.287	0.304	0.327	0.318	0.337			
2010	0.285	0.277	0.293				0.491	0.477	0.505
2011	0.286	0.278	0.295	0.317	0.309	0.326			

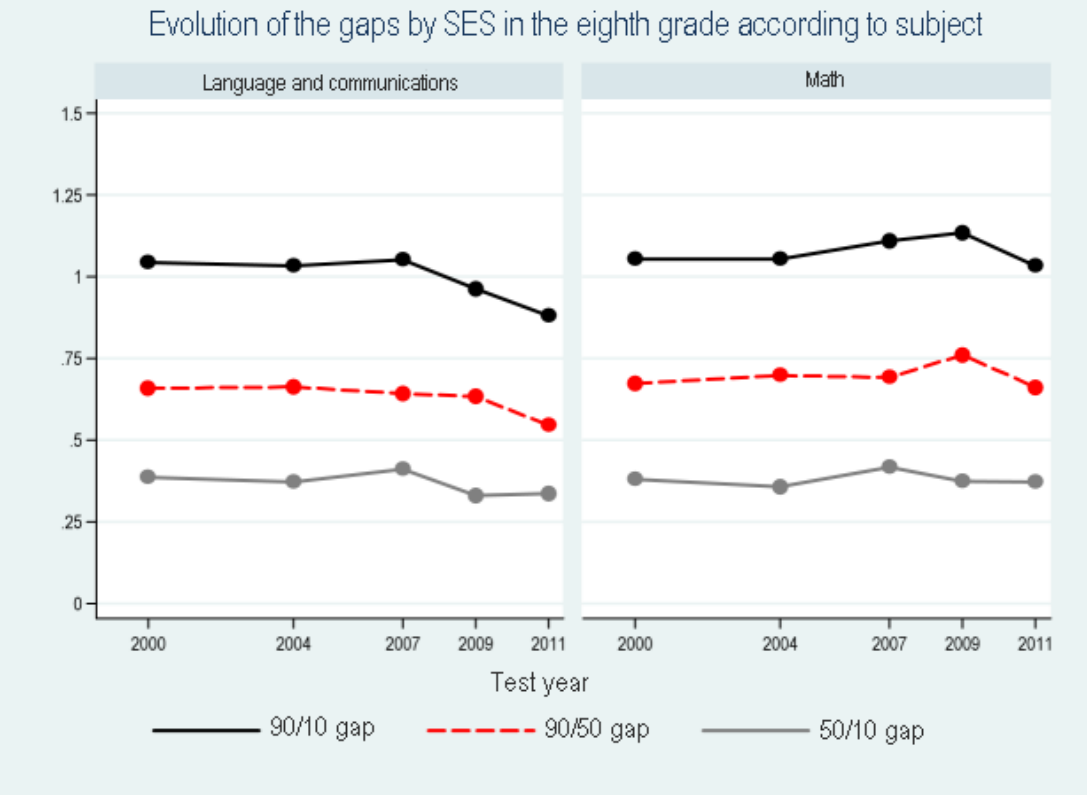
Note: Upper and lower limits of the ICC confidence interval are estimated at a 95% confidence level.

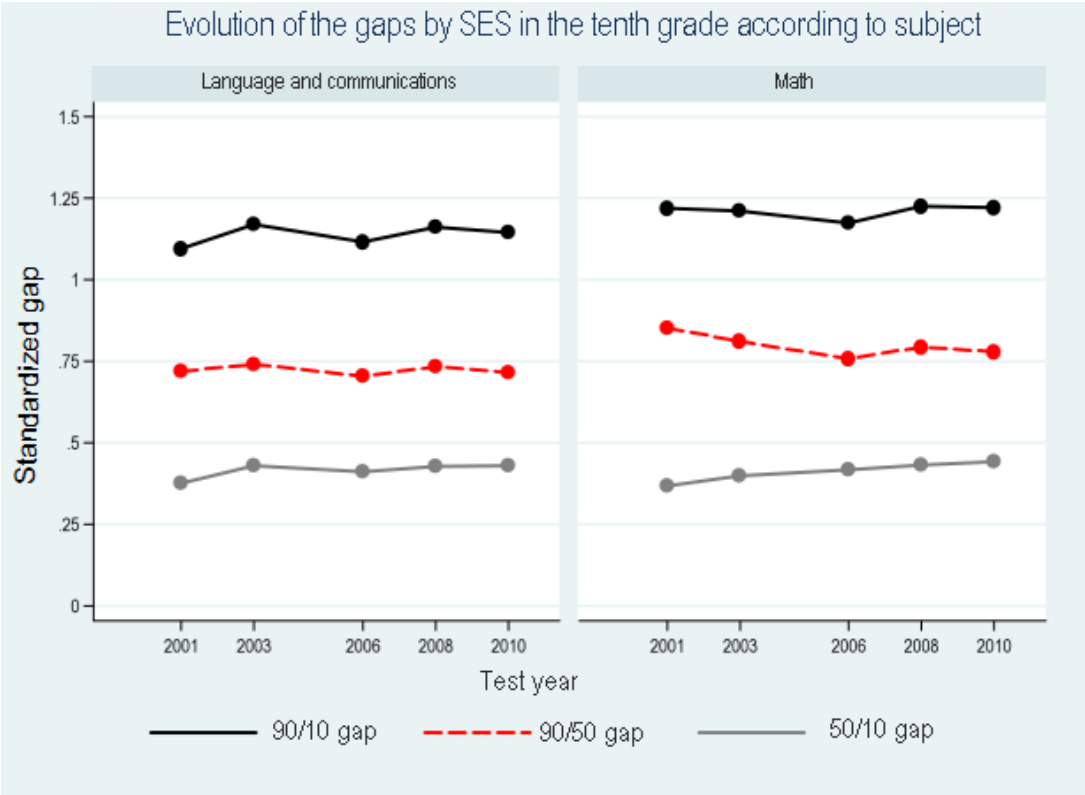
Panel B: Language Test

	Fourth grade			Eight grade			Tenth grade		
	ICC	Lower Limit	Upper Limit	ICC	Lower Limit	Upper Limit	ICC	Lower Limit	Upper Limit
1999	0.305	0.296	0.314						
2000				0.260	0.250	0.269			
2001							0.338	0.323	0.354
2002	0.276	0.268	0.285						
2003							0.368	0.353	0.383
2004				0.255	0.247	0.263			
2005	0.235	0.228	0.243						
2006	0.206	0.199	0.213				0.369	0.355	0.383
2007	0.218	0.210	0.226	0.258	0.250	0.266			
2008	0.214	0.207	0.221				0.385	0.371	0.398
2009	0.211	0.204	0.218	0.247	0.239	0.255			
2010	0.195	0.188	0.202				0.385	0.371	0.399
2011	0.191	0.185	0.198	0.258	0.249	0.266			

Note: Upper and lower limits of the ICC confidence interval are estimated at a 95% confidence level.

Appendix 5. Evolution of learning gaps according to SES and student family income, eighth grade, for selected percentiles





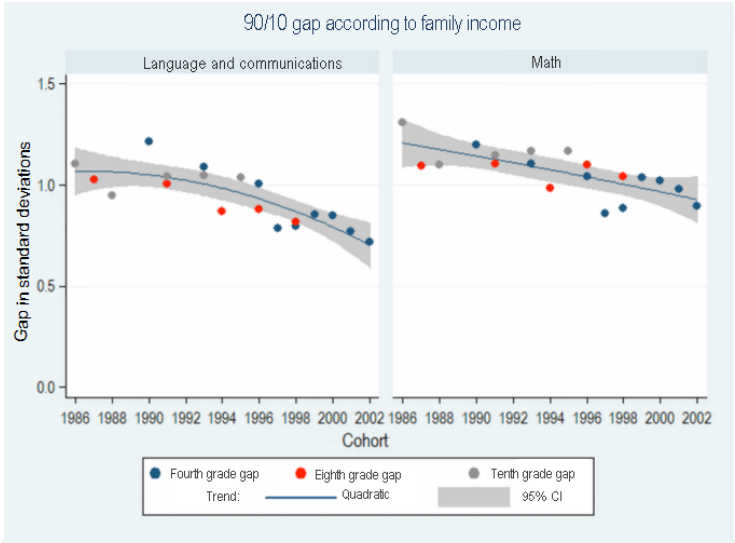
Appendix 6

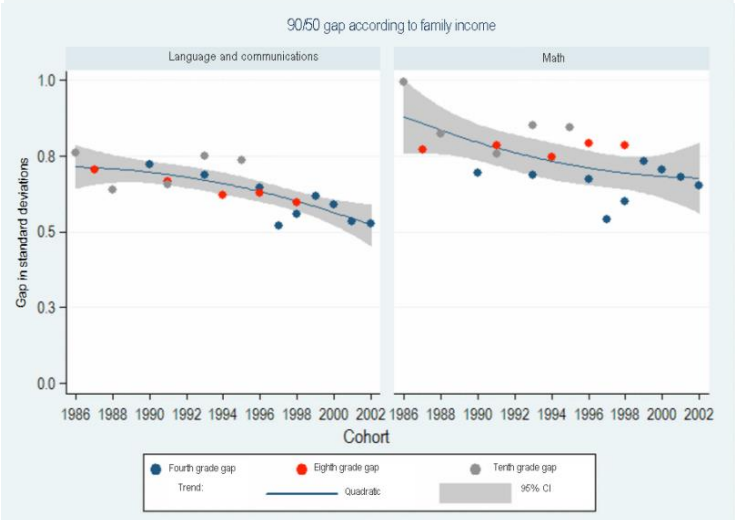
Decrease in learning gaps according to SES by approximate birth cohort, 1986-2002

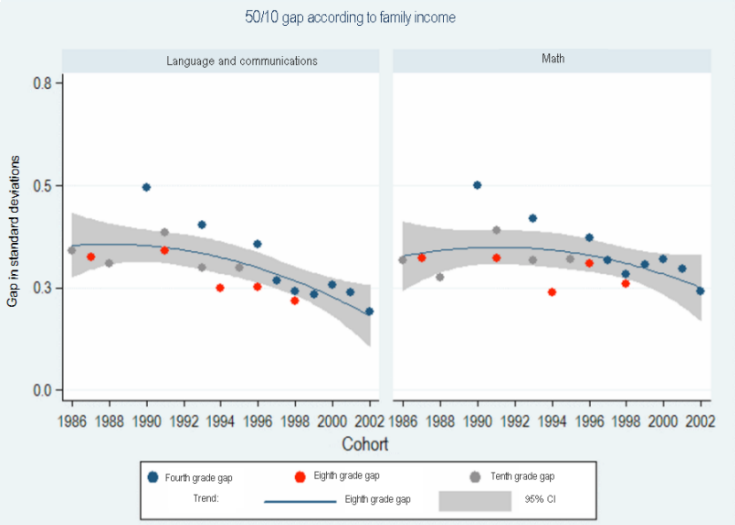
	All tests			
	Language		Math	
Gap	(b/se)	Fit	(b/se)	Fit
90/10	-0.025**	Quadratic	-0.010**	Linear
	(0.003)		*(0.004)*	
90/50	-0.015**	Quadratic	-0.008**	Linear
	(0.002)		*(0.003)*	
50/10	-0.009**	Quadratic	-0.003	Quadratic
	(0.002)		*(0.002)*	
80/20	-0.013**	Quadratic	-0.004	Linear
	(0.002)		*(0.003)*	

Note: Standard errors in parentheses. Samples included in the analysis: 19.
Significance levels: ** p<0.01, * p<0.05, + p<0.10

Appendix 7. Evolution of learning gaps according to student family income, eighth and tenth grades, for selected percentiles







Appendix 8

Decrease in learning gaps according to family income per approximate birth year, 1986-2002

	All tests			
	Language		Math	
Gap	(b/se)	Fit	(b/se)	Fit
90/10	-0.029**	Quadratic	-0.017**	Linear
	(0.004)		*(0.004)*	
90/50	-0.012**	Linear	-0.013**	Linear
	(0.002)		*(0.004)*	
50/10	-0.014**	Quadratic	-0.008**	Quadratic
	(0.003)		*(0.003)*	
80/20	-0.012**	Linear	-0.008**	Linear
	(0.003)		*(0.003)*	

Significance levels ** p<0.01, * p<0.05, + p<0.10