The Impact of Multigrade Classes on Student Achievement in Canada

Gino Santarossa
Center for Information and Research in Economics and Evaluation (ciree.ca), Quebec, Canada, G3A 1E2, santarossagino@gmail.com

Abstract

Objective Multi-grade classes represent an instructional model in which students from different grade levels share the same classroom. In a context where the empirical effects of this pedagogical arrangement remain scarcely documented in Canada, the present study aims to evaluate the impact of multi-grade classes on the academic achievement of third-grade students in Ontario.
Methods Using publicly available school-level aggregated data, two evaluation approaches are employed to account for the potential endogeneity of the number of students in multi-grade classes. The first method, an instrumental variable regression, relies on a prediction rule for the number of students in multi-grade classes, based on third-grade enrollment figures and considering the discontinuities observed at thresholds corresponding to the maximum regulated class size for third grade or its multiples. The second method, a regression discontinuity design, directly exploits these discontinuities in the distribution of students across multi-grade classes. A difference-in-differences version of this method further allows for a more rigorous consideration of unobservable differences around the discontinuity thresholds.
Results The results obtained from these methods indicate that multi-grade classes exert an adverse effect on academic achievement. Moreover, the magnitude of these negative effects increases with the number of third-grade students who share their learning environment with students from adjacent grade levels.

JEL classification: I21, C26.
Keywords: Education, multi-grade classes, IV, RDD.

1 Introduction

Multigrade classes (MGCs) bring together, within a single classroom and under the responsibility of one teacher, students from adjacent grade levels. They may be implemented as part of a pedagogical approach designed to promote students' academic achievement. For school administrators, they also represent a means of optimizing the use of educational resources, notably by maximizing class size under current regulations.

MGCs can affect students' educational achievement in a positive, negative, or null way. For instance, Borbely et al. (2023), using an instrumental variables approach, estimated that the presence of second-grade students in primary school MGCs in Scotland contributes positively to the academic achievement of first-grade students in the same classes. Conversely, Checchi and De Paloa (2018) found that fifth-grade primary students in Italy perform worse in literacy and numeracy when enrolled in MGCs. Sims (2008) reported similar negative effects among second- and third-grade primary students in California, United States. However, Thomas (2012) contradicted these findings later, who, using a doubly robust estimation strategy, concluded that MGCs have no effect on the academic achievement of these same students.

Several factors might explain these mixed effects. According to Leuven and Rønning (2016), who found a positive impact of MGCs on secondary school students in Norway, the benefits associated with this class type depend on maintaining a balanced group composition. Specifically, their findings suggest that students' academic achievement may suffer if the negative effects associated with lower grades outweigh the advantages brought by peers from higher grades. Hyry-Beihammer and Hasher (2015) highlight this class-pair collaboration strategy, in which teachers adjust their pedagogical practices according to group heterogeneity to ensure the success of multi-grade classrooms.

Using longitudinal data, Barbetta et al. (2023) reported that the short-term positive effects of MGCs gradually turn negative in the years following the second grade of primary school, unless teachers have more experience. Finally, Quail and Smyth (2014) found no average effect of MGCs on nine-year-old students in Ireland. However, they noted that the educational achievement of girls who shared classes with older peers in MGCs was lower than that of girls enrolled in single-grade classes.

In summary, the diversity of age, skills, and maturity levels in multi-grade classes may foster students' cognitive development (Checchi and De Paloa, 2018; Lloyd, 1999). However, these same factors, or others, may also, depending on students' relative positions within the distribution of such characteristics, influence academic achievement in contrasting ways. This is evidenced by several studies on peer effects (Carman and Zhang, 2012; Gottfried, 2012; Ewijk and Sleegers, 2010). Furthermore, researchers question whether younger students fully benefit from the presence of older peers in the classroom (Haeck et al., 2022; Boucher et al., 2012).

On the teachers' side, targeted training for instruction in MGCs can enhance their teaching effectiveness (Mulryan-Kyne, 2007). However, teaching in MGCs may also compromise students' academic achievement due to the simultaneous management of

multiple pedagogical objectives, increased demands from students, and potentially higher stress levels associated with the complexity of the task (Burn and Mason, 2002).

No recent studies have examined the empirical effects of MGCs on educational achievement in Canada. The few available monographs draw primarily on meta-analyses from the 1990s and 2000s, and on empirical studies conducted during that period (Lataille-Démoré, 2007, 2008; Mason and Burn, 2002; Veenman, 1995, 1996). It's therefore relevant to investigate the contemporary effects of MGCs in the Canadian context, given the widespread implementation of this class across most Canadian provinces and the findings emerging from recent international research.

Thus, the objective of this study is to estimate the effects of MGCs on the academic achievement of Grade 3 students within Ontario's public school system, using data from the Ontario Ministry of Education's public data catalogue (Ontario Ministry of Education, 2025). According to these data, 2,537 out of 2,842 elementary schools (89.3%) offered multi-grade classes for Grade 3 students during the 2022–2023 school year. Consequently, 49,041 out of 113,807 Grade 3 students (43.1%) attended MGCs during the same period.

Moreover, the average proportion of Grade 3 students meeting the provincial standard in reading, writing, and mathematics stood at 71.3%, 63.6%, and 58.2%, respectively, in schools with MGCs. In contrast, in schools without MGCs, these proportions reached 77.6%, 69.6%, and 66.3%, respectively, indicating a notable performance gap. The present study seeks to determine the extent to which these disparities can be attributed to the presence of multi-grade classrooms.

To achieve this objective, I employ a treatment effect evaluation framework, following in part the approach of Sims (2008). I use school-level aggregated data on achievement rates, as well as school and socioeconomic factors, and classroom-level data on the number of Grade 3 students enrolled in MGCs. The discontinuities observed in the number of students enrolled in MGCs at the regulatory class-size thresholds for Grade 3 and its multiples allow, following Angrist and Lavy (1999), the use of an instrumental variable (IV) strategy. In this case, the instrument corresponds to a predictive rule for the expected number of students in MGCs. Ultimately, including a control group allows for the use of a regression discontinuity method in conjunction with a difference-in-differences strategy. This approach aims to determine the localized average treatment impact on schools with MGCs (Takahashi, 2025; Grembi et al., 2016).

Using school-level aggregated data offers the advantage of capturing not only the direct effects of MGCs on the performance of students enrolled in them, but also their indirect effects on the overall functioning of the school. Indeed, the presence of MGCs may influence student allocation, collective teaching practices, and even the school climate, all factors likely to affect the average academic achievement of students within the institution (Checchi and DePaola, 2018). However, this global approach prevents an empirical distinction between the respective shares of direct and indirect effects, thereby limiting the precision of causal interpretation.

This study contributes to the literature on multi-grade classes in two main ways. First, it enriches a still limited international body of research examining the empirical effects of

MGCs. Second, it represents one of the few empirical investigations conducted in Canada on this topic. The results indicate that MGCs negatively affect the academic achievement of Grade 3 students in Ontario, according to both evaluation methods employed, thereby corroborating the statistical disparities described earlier.

The remainder of the study is structured as follows: Section 2 describes the data used and presents descriptive statistics comparing schools with and without multi-grade classes. This section also outlines the predictive rule for estimating the number of students enrolled in MGCs. Section 3 details the econometric methods employed. The empirical results are presented in Section 4, and Section 5 concludes.

2. Data and descriptive analysis

2.1 Data

The public data from the Ontario Ministry of Education contain two datasets relevant for analyzing multi-grade classes. The first dataset provides class-level information, primarily the number of students per grade level composing each Grade 3 class in a school. The second dataset offers school-level and socioeconomic data. Specifically, it includes the percentages of Grade 3 students meeting the provincial standard in reading, writing, and mathematics, which serve as indicators of academic achievement to estimate the effects of MGCs.

The school-level socioeconomic data include the following variables: the percentage of students whose first language isn't English; the percentage of recent immigrants to Canada from non-English- or non-French-speaking countries; the percentage of students receiving support for children with special educational needs; the percentage of students identified as gifted; the percentage of students living in low-income households; and the percentage of students whose parents hold no certificate, diploma, or degree. These observable factors partially account for the endogenous allocation of students into MGCs (Checchi and De Paola, 2018; Burns and Mason, 2002).

Combining the two datasets yields a panel of 2,859 elementary schools observed over the 2017–2018 to 2022–2023 school years, which totalizes 14,295 observations[1]. This panel structure makes it possible to control fixed and unobservable confounding factors at the school board level, and for year effects.

[1] Schools with more than 120 Grade 3 students or with more than 80 students enrolled in MGCs didn't make it onto the panel because of their insufficient number for implementing regression discontinuity estimates. Also, observations from the 2019–2020 school year were also excluded, given the disruptive impact of the COVID-19 pandemic on the education system.

2.2 Descriptive statistics

The *Ontario Education Act* stipulates that at least 90% of Grade 3 classes must consist of 20 students or fewer[2]. This legislative requirement incentivizes school boards to adopt management strategies aimed at maximizing class sizes, primarily to minimize the number of teachers needed. As shown in Figure 1, the average class size observed in 2022–2023 was approximately 20 students, regardless of the number of Grade 3 students enrolled in each school. This pattern contrasts with the implications of Maimonides' Rule (Angrist and Lavy, 1999), as illustrated, for instance, in Leuven and Rønning (2016).

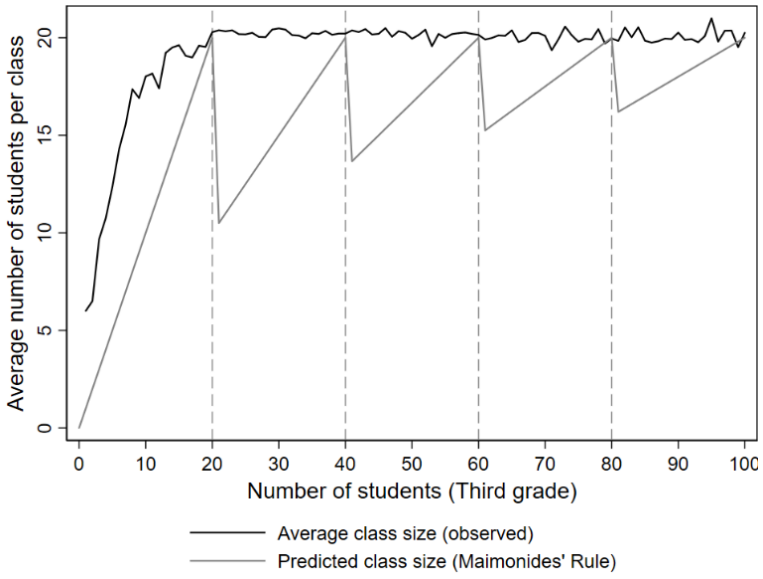

FIGURE 1 Observed and Predicted Average Class Size for Grade 3 Students (Maimonides' Rule), Ontario Schools, 2022–2023.
SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

Multi-grade classes, which combine Grade 3 students with those from Grade 2 or Grade 4, represent the most natural means of maximizing the number of students per class. As shown in Figure 2, which displays the number of students in MGCs as a function of total Grade 3 enrollment, such classes are implemented in most schools, although a significant number of schools don't use them.

[2] The province sets the maximum class size at 23 students for the remaining 10%, as stipulated in the Education Act, Ontario Regulation 132/12, Sections 5(1) and 5(2), government of Ontario, 2024.

Figure 2 is of interest for several reasons[3]. First, it illustrates the decisions made by schools regarding the composition of MGCs. As previously mentioned, some schools choose not to implement such classes, regardless of the number of students enrolled in Grade 3[4]. As a result, the number of students per class often falls below the regulatory limit. For instance, data analysis reveals that three schools with 34 Grade 3 students each formed two classes of 17 students for the 2022–2023 academic year. Moreover, eight additional schools, comprising 55 Grade 3 students, organized three distinct classes at this level**.** One of these schools, for instance, distributed its students across three classes of 16, 19, and 20 students, respectively.

As evidenced in the data, the range of possible student groupings into MGCs expands with increasing cohort size. Two configurations are observed in schools enrolling fewer than 20 Grade 3 students (quadrant 1 of Figure 2): either no MGC exists, or the school incorporates the entirety of the Grade 3 cohort into an MGC. In the latter scenario, for instance, a school with 10 Grade 3 students and one Grade 4 student assigned to the same classroom would report all 10 Grade 3 students as part of an MGC.

For schools with Grade 3 enrollments ranging from 20 to 39 students (quadrants 2 and 8 of Figure 2), three distinct grouping patterns are observed. The first involves no inclusion of Grade 3 students in an MGC. The second corresponds to partial integration, whereby few Grade 3 students are assigned to MGCs (as illustrated in quadrant 2 of Figure 2). This number tends to increase proportionally with cohort size, up to the threshold of 40 students, beyond which the formation of a second standalone Grade 3 class becomes feasible. Finally, the third pattern consists of full integration, where all Grade 3 students attend MGCs (as seen in quadrant 8 of Figure 2).

Within the group of schools enrolling between 40 and 59 Grade 3 students (quadrants 3, 9, and 15 of Figure 2), four distinct grouping patterns are identified. The first subgroup includes no Grade 3 students in MGCs. The second involves a few students in MGCs (quadrant 3 of Figure 2, ranging from 1 to 19). The third reflects a more substantial participation of Grade 3 students in MGCs (quadrant 9 of Figure 2, ranging from 20 to 39 students). The fourth subgroup comprises schools where all Grade 3 students are assigned to MGCs (quadrant 15 of Figure 2). This distributional pattern tends to repeat at each threshold corresponding to a multiple of the regulatory class size (i.e., 20 students), which leads to the formation of an additional multi-grade grouping.

[3] Figure 2 was divided into 24 quadrants to facilitate its analysis. The vertical lines correspond to the conventional class size threshold (20) and its multiples, while the horizontal lines indicate the grouping thresholds for the number of students in multi-grade classes.

[4] 302 out of 2,833 primary schools didn't form any MGCs during the 2022–2023 school year.

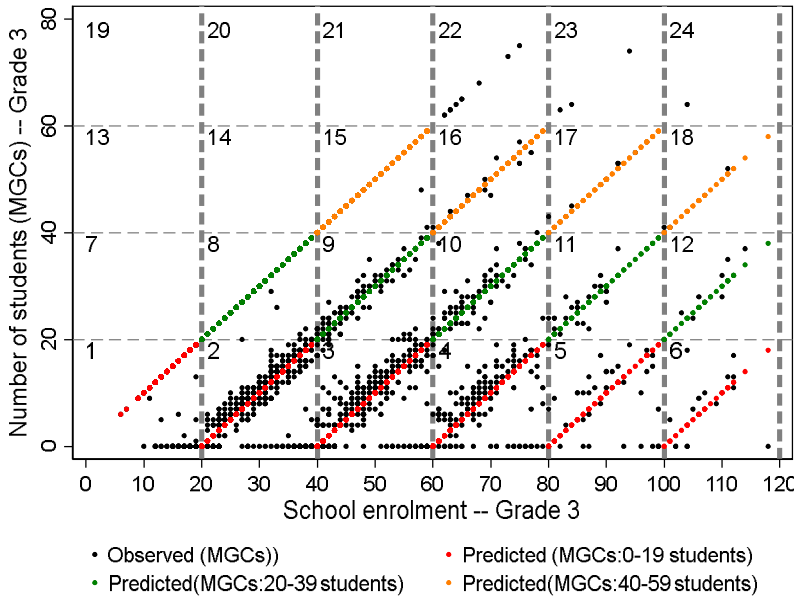

FIGURE 2 Observed and Predicted Number of Grade 3 Students in Multigrade Classes, Ontario Primary Schools, 2022–2023.

NOTES: This graph displays the observed and predicted numbers of third-grade students in multi-grade classes as a function of total third-grade enrollment. The red dots represent the predicted values for the group of schools with 0 to 19 third graders in multi-grade classes. The green and orange points correspond to the predicted values for schools with, respectively, 20 to 39 and 40 to 59 third-grade students in multi-grade classes.

SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

Like Maimonides' rule, the number of students in multi-grade classes is instrumented using total school enrollment. This approach makes it possible to predict the number of students in multi-grade classes based on school enrollment while accounting for the observed discontinuities.

Let n_i denote the number of Grade 3 students in school i, where the maximum class size is set at 20, and let M_i represent the number of students at the same grade level who are grouped into MGCs. The prediction rule for the number of students in MGCs in school i can thus be expressed as follows:

$$M_{ij} = j + \left(n_i - int\left(\frac{n_i}{20}\right) * 20\right)$$
$$M_i = \sum_j^{60} d_{i,j} M_{i,j}\,,$$
$$\text{where } d_{i,j} = 1 \text{ if } K \in [j, j+19], \text{ or } d_{i,j} = 0 \text{ otherwise,}$$
$$j = 0, 20, 40, 60, \qquad (1)$$

where K_i denotes the number of students observed in the MGCs of school i. In this equation, the function int(x) represents the floor of x, that is, the greatest integer less than or equal to x. The parameter j can take four values: 0, 20, 40, or 60, each corresponding to a range of student counts within the MGCs. Accordingly, $j = 0$ defines the prediction rule

for schools whose number of MGC students ranges from 0 to 19 (red dots in quadrants 1 to 6 in Figure 2. $j = 20$ specifies the prediction for schools where the total number of third-grade students in MGCs lies between 20 and 39 (green dots in quadrants 8 to 12 in Figure 2), while $j = 40$ applies to schools with MGC enrollments between 40 and 59 students (orange dots in quadrants 15 to 18 in Figure 2). Finally, $j = 60$ corresponds to the case in which the number of MGC students ranges from 60 to 79.

The predicted number of students in MGCs, according to the four strata defined above, is used as an instrumental variable in the first stage of the two-stage least squares (2SLS) estimation. In this approach, the main source of exogenous identification of the MGCs impact arises, on the one hand, from the prediction rule itself, and on the other, from the predicted discontinuities occurring at points corresponding to the maximum class size in the third grade or its multiples. This strategy also accounts for observable confounding factors, particularly the percentage of students experiencing learning difficulties within schools. This provides a robust estimate of the causal effect of MGCs.

To assess the potential effects of MGCs, and more specifically the heterogeneity of these effects depending on the number of Grade 3 students within MGCs, Table 1 presents three comparisons focusing on academic achievement and the socioeconomic profile of schools for the 2022–2023 academic year. The first comparison contrasts schools without MGCs with those having between 1 and 19 Grade 3 students enrolled in MGCs (columns 1 to 3 of Table 1). Indicators of academic achievement reveal statistically significant differences of approximately three to five percentage points for schools without MGCs[5]. Moreover, these differences are observed in a context where only the proportions of students whose parents don't hold a diploma, newly arrived students from English-speaking countries, and public schools show statistically significant, albeit varying, differences between the two groups.

The potential impact of MGCs on academic achievement can also be examined by comparing schools with 1 to 19 Grade 3 students in MGCs to those with 20 to 39 students (columns 2, 4 and 5 of Table 1). Statistically significant differences in academic achievement are observed for the first group of schools. On average, schools in this group show a reading proficiency rate that outperforms that of schools with 20 to 39 MGCs students by 2.7 percentage points. The corresponding differences for writing and mathematics amount to 3.2 and 4.2 percentage points, respectively.

[5] Note that this study only has access to data aggregated at the school level. Consequently, the differences in academic achievement presented in Table 2 stem from school-level averages, which may underestimate the true disparities if more granular data, at the class or student level, became available. The following example illustrates the likely magnitude of this underestimation: School A, which doesn't have MGCs, has an average achievement rate of 75%. School B, on the other hand, has 28% of its Grade 3 students enrolled in MGCs, with an average achievement rate of 68%. The average achievement of the other students at School B, not enrolled in MGCs (72%), stands at 75%. Thus, within School B, the intra-school achievement gap between regular classes and MGCs reaches seven percentage points. In contrast, the interschool gap between Schools A and B amounts to 1.96 points, corresponding to the difference between School A's average achievement (75%) and the weighted average achievement of School B (73.04%).

Moreover, socioeconomic differences between the two groups remain relatively modest and statistically non-significant. Nevertheless, it's worth noting that the indicators of educational and socioeconomic disadvantage, specifically, the percentage of students experiencing learning difficulties (13.9%) and the proportion of students from low-income families (5.0%), are statistically and significantly higher in the second group of MGCs than in the first. This partly aligns with the observations of Thomas (2012).

Furthermore, Table 1 highlights notable differences in the composition of MGCs. First, as expected, the ratios of third-grade students in MGCs compared to those in the second grade (3rd grade MGCs/2nd grade MGCs) or fourth grade (3rd grade MGCs/4th grade MGCs) vary. Specifically, in schools where the number of third-grade students in MGCs equals or exceeds 20, these ratios average 1.5, indicating an overrepresentation of third grade compared to those from other grades in multi-grade classrooms[6]. These findings could indicate a minority grouping of second- or fourth-grade students within third-grade classes.

Conversely, in schools with 1 to 19 third-grade students in MGCs, the ratios average only 0.7 and 0.5 for class-sharing with second- and fourth-grade students, respectively. In this case, these data can be interpreted as indicating a minority grouping of third-grade students within second- or fourth-grade classes. Moreover, in both groups of schools (1–19 and 20–39), third-grade MGCs students share their classes with second-grade students. The proportions are 57.0% and 51.6%, respectively, which stand about 3 to 5 percentage points higher than that observed for fourth-grade students (42.6% and 48.0%). Consequently, class-sharing with second-grade students appears, on average, more frequent.

As a final comparison, schools with 40 to 59 students in MGCs exhibit lower academic performance across all subjects compared to schools with 20 to 39 MGC students. This difference becomes more pronounced relative to the first two groups: schools without MGCs and those with 1 to 19 MGC students. As shown in Table 1, third-grade students in the third MGC group (40 to 59 students) are predominantly compared to students from other grades. These include second grade (3rd grade MGC/2nd MGC ratio = 1.7) and fourth grade (3rd grade MGC/4th grade MGC ratio = 2.0). Moreover, a higher percentage of third-grade students in MGCs share their class with older, fourth-grade students (53.0%) than with younger, second-grade students (46.7%).

[6] For a class of 20 students, a ratio of 1.5 corresponds to a grouping of 12 third-grade students, with 8 second-grade students, or with 8 fourth-grade students.

Table 1—Comparative statistics

Numbre of 3rd grade students : 20 <= N < 100	MGCs (N)				MGCs (N)			MGCs (N)		
Variable	0 (1)	[1,19] (2)	(2)-(1) (3)		[20,39] (4)	(4)-(2) (5)		[40,59] (6)	(6)-(4) (7)	
Academic achievement (Students meeting the provincial standard (%))										
Reading	77.7	73.4	-4.3	*	70.6	-2.7	*	67.1	-3.5	*
Writing	69.7	66.2	-3.5	*	63.0	-3.2	*	59.6	-3.5	
Mathematics	66.1	61.2	-4.9	*	57.0	-4.2	*	54.3	-2.7	
Socioeconomic factors										
Students at risk (%)	12.3	12.8	0.5		13.9	1.1	*	12.2	-1.7	*
Gifted students (%)	0.7	0.5	-0.2		0.8	0.3		0.3	-0.5	
Students whose parents have no diploma (%)	7.9	8.9	1.0	*	9.3	0.4		9.2	-0.1	
Students from low income families (%)	4.4	4.4	0.0		5.0	0.6	*	4.4	-0.6	
Newly arrived students,non-English-speaking coun	4.9	6.0	1.1	*	6.0	0.1		6.0	0.0	
Newly arrived students,non-French-speaking count	5.8	6.6	0.8		6.5	-0.1		6.7	0.2	
School factors										
Public schools (%)	60.2	71.4	11.2	*	77.2	5.8	*	90.8	13.7	*
Number of 3rd grade classes	2.4	3.0	0.6	*	3.2	0.2	*	4.7	1.5	*
Average class size of 3rd grade	19.4	20.0	0.5	*	20.5	0.5	*	20.7	0.2	
Multi-grade class composition (MGCs)										
Number of 3rd grade students in MGCs		11.4			26.6	15.2	*	46.9	20.3	*
Percentage of 3rd grade students in MGCs		28.2			74.6	46.5	*	85.1	10.4	*
Number of MGCs, 3rd grade with 2nd grade students		0.7			1.3	0.6	*	2.1	0.8	*
Percentage of 3rd grade with 2nd grade students		57.0			51.6	-5.4	*	46.7	-4.9	*
Ratio : Grade 3 MGCs (N) / Grade 2 MGCs (N)		0.7			1.5	0.8	*	1.7	0.2	
Number of MGCs, 3rd grade with 4th grade students		0.6			1.1	0.5	*	2.0	0.9	*
Percentage of 3rd grade with 4th grade students		42.6			48.0	5.4	*	53.0	5.1	*
Ratio : Grade 3 MGCs (N) / Grade 4 MGCs (N)		0.5			1.5	1.0	*	204.9	0.6	*
Number of schools	***226***	***1 017***			***955***			***109***		

* Welch's t-test; Statistically significant difference at the 5 % confidence level

NOTES: The table compares academic achievement, the socioeconomic status of schools, and the composition of multi-grade classes across schools grouped by different Grade 3 student configurations.
SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

3 Methodology

Our objective is to estimate the average effects of MGCs on academic achievement, using school-level data. This analysis unfolds in a context where considerations related to class size management primarily drive schools' participation in this educational measure, as illustrated in Figure 1. However, both school participation and the allocation of students to MGCs may also depend on observable and unobservable factors, such as age, socio-emotional maturity, or the degree of learning difficulty. These could act as confounding variables in the estimation of the effects of MGCs on academic achievement (Borbely et al., 2023).

I first seek to estimate the local average treatment effect (LATE) of third-grade MGCs enrollment on student achievement at the same grade. The identification strategy follows the standard instrumental variables approach of Angrist and Lavy (1999) and Angrist, Leder-Luis and Shany (2019) in the class size literature. Specifically, I instrument MGCs

enrollment with the predicted number of third-grade students assigned to MGCs, based on the cohort size rule formalized in Equation (1). As shown in Figure 2, this rule strongly predicts MGCs enrollment and leverages discontinuities in multigrade class sizes as an exogenous source of variation to identify the causal effect of MGCs.

Student academic achievement at the school level is modeled as follows:

$$M_{it} = \delta M_{it}^{p} + \pi X_{it} + \tau_t + \varepsilon_{it}, \tag{2.1}$$

$$Y_{it} = \theta \widehat{M_{it}} + \beta X_{it} + \alpha_t + \gamma_j + u_{it}, \tag{2.2}$$

where M_{it} denotes the number of Grade 3 students enrolled in multi-grade classrooms in school *i* in year *t,* and, M_{it}^{p} is the predicted number of students in MGCs based on the exogenous rule defined in the equation (1). The vector X_{it} includes covariates that may influence both student achievement and a school's participation in the MGCs policy, specifically the proportion of students with learning difficulties and the socioeconomic status of parents. The terms τ_t and α_t represent year effects in the first stage and second-stage equations, respectively, while γ_j captures school boards fixed effects. The components $\varepsilon_{it}$and $u_{it}$are random error terms.

Finally, $\widehat{M_{it}}$ represents the predicted number of Grade 3 students in multi-grade classes, conditional on all deterministic components specified in the equation (2.1). These additional components enable the model to account for schools' partial compliance with the enrollment-counting rule for MGCs, particularly in cases where schools don't implement multi-grade classes. It's worth noting that if $\pi = 0$, $\tau_t = 0$ and $\varepsilon_{it} = 0$, the model simplifies to a sharp Regression Discontinuity Design.

I then rely on the regression discontinuity (RD) design, applied to observations near the thresholds of 20, 40 and 60 third-grade students, to estimate the effect of the MGCs. It's worth recalling that the discontinuities observed in the number of students in MGCs at these thresholds partly stem from Ontario's educational regulations, which cap third-grade class sizes at 20 students.

Two versions of the regression discontinuity (RD) method are applied: the standard RD and the difference-in-differences regression discontinuity (RD-DD). The standard RD approach relies on the assumption that only the running factor, in this case, school enrollment size, drives the observed discontinuities in the number of third-grade students within MGCs. It implicitly exploits them to estimate their impact on academic achievement.

Other confounding factors, whether observable or unobservable, are assumed to cause zero impact on the discontinuities in the number of students across MGCs. However, this assumption appears somewhat unrealistic, since, as illustrated in Figure 2, schools may display different counts of third-grade students in MGCs for total enrollment, particularly near the discontinuity thresholds. Factors other than total school size might likely influence these choices. The standard RD method, applied exclusively to schools with MGCs, can

account for observable confounding factors. Within this analytical framework, the estimated treatment parameter corresponds to the Local Average Treatment Effect (LATE).

The RD-DD method, for its part, provides a relevant approach to addressing potential biases arising from unobserved differences at the margins of the discontinuity thresholds. This method has experienced increasing attention in recent years, particularly following the work of Grembi, Nannicini, and Troiano (2016). More recently, Takahashi (2025) formalized this estimator and demonstrated that the RD-DD design identifies the Local Average Treatment Effect on the Treated (LATT).

The impact of MGCs within the RD-DD framework is estimated using Ordinary Least Squares (OLS) applied to the model specified in Equation (3):

$$Y_{i,t} = \alpha + \delta d_G + \gamma d_T + \theta(d_G \times d_{T)} + \beta X_{it} + \alpha_t + \gamma_j + u_{it}. \quad (3)$$

In this equation, d_G is a treatment group indicator variable, corresponding to one of three groupings of students in MGCs, namely G = [1,19], [20,39], or [40,59]. A value of zero for this variable identifies schools without MGCs, which form the control group, while a value of one identifies one of the three aforementioned groups. The binary variable d_T identifies one of the three third-grade enrollment thresholds that generate discontinuities in the number of students enrolled in MGCs, specifically T = 20, 40, or 60 students. Accordingly, d_{20} = 1, d_{40} = 1, and d_{60} = 1 respectively denotes schools with at least 20, 40, and 60 third grade students. All other variables in the model have been defined previously.

Equation (3) is estimated over three intervals of third-grade enrollment in Ontario's elementary schools, namely [15,24], [35,44], and [55,64]. An estimation is performed separately for each treatment group available within these intervals. To illustrate the procedure, let us focus on the group of schools with 35 to 44 third-grade students, whose number of students in MGCs ranges between 1 and 19. This group of schools falls under quadrants 2 and 3 of Figure 2.

In the context of the standard RD regression, where schools without MGCs are excluded from the estimation, the parameters δ and θ in equation (3) are set to 0. Consequently, the parameter γ is the local average treatment effect (LATE) of MGCs for the group of schools with 40 to 44 third-grade students, while accounting for the vector X of potentially confounding school-level and socioeconomic variables, as well as school board fixed effects (γ_j) and year fixed effects (α_t).

Within the RD-DD framework, where observations from the control group are included in the estimation, the parameter δ represents the average effect of MGCs for the treatment group with 1 to 19 students in MGCs ($d_{[1,19]} = 1$), conditional on the other explanatory factors in the model. The parameter θ, in turn, captures the localized average treatment effect of MGCs on participating schools. The estimation of this effect thus accounts for unobservable differences between schools with 35 to 39 third-grade students and those with 40 to 44 third-grade students, through including the control group.

4. Results

I now present the results of this study. The analysis begins with an examination of the factors that lead, on the one hand, to schools to include MGCs within their institutions, and on the other hand, to determine the number of students in these classes (Section 4.1). Subsequently, the impact of MGCs is estimated using the ordinary least squares (OLS) and two-stage least squares (2SLS) approaches (Section 4.2). Finally, the section concludes with an analysis of the results obtained from the regression discontinuity estimations (Section 4.3).

4.1 Participation in MGCs

Figure 2 showed that the number of students in MGCs increases with school enrollment, starting from the thresholds corresponding to the maximum class size or its multiples. This pattern makes sense, as schools tend to maximize class size to optimize the use of teaching resources. However, questions remain regarding the other factors that lead schools to resort to MGCs and to accommodate a greater or a smaller number of students in them for a level of total enrollment.

Table 2 presents the estimates from a Probit regression (column [2]), in which the dependent variable indicates whether a school implements MGCs or not. Column (1) of the same table reports the estimates of the equation (2.1). This is the regression of the number of students in MGCs on the predicted number of students in these classes (from equation [1]), a vector of socioeconomic factors and class size. The latter variable serves as an additional instrument, as it hasn't been shown to affect academic achievement.

The Probit regression results indicate that schools' socioeconomic disadvantage increases their likelihood of implementing MGCs. Specifically, a higher share of students receiving early childhood education support and students whose parents don't have a certificate, diploma, or degree increases this probability. Conversely, a higher proportion of gifted students reduces it. Interestingly, the percentage of students facing learning difficulties is, on average, associated with fewer students in MGCs, as shown in column (1) of Table 2.

Furthermore, public and English-language schools exhibit a higher propensity to implement multi-grade classes and correlate with more third-grade students sharing their classrooms with second- or fourth-grade peers. Finally, although third-grade class sizes don't differ significantly across schools, they positively affect both the likelihood of adopting MGCs and the number of students integrated into them.

TABLE 2
Regression Results : Participation and Number of Students in MGCs

Dependent variables :	2017-2018 to 2022-2023 Number of students in MGCs	Participation in MGCs (yes/no)
	(1)	(2)
Method :	OLS	Probit (Marginal effects)
Annual effect :	yes	yes
School and socioeconomics factors		
Students receiving special educ.services (%)	-0.041***	0.003***
	(0.013)	(0.000)
Gifted students (%)	-0.024	-0.002***
	(0.026)	(0.001)
School-Aged Children in Low-Income Household (%)	0.032***	0.001*
	(0.012)	(0.000)
Students Whose Parents Have No Diploma	-0.005	0.001*
	(0.014)	(0.000)
New students to Canada from a Non-English speaking country (%)	0.053***	0.000
	(0.016)	(0.000)
Public schools (yes/no)	2.440***	0.015**
	(0.204)	(0.007)
English schools (yes/no)	6.133***	0.144***
	(0.300)	(0.010)
Grade 3 students in multi-grade classrooms	1.627***	0.026***
	(0.041)	(0.001)
Number of schools	2 761	2 761
Number of observations	12 288	12 288

NOTES: The first column in this table reports the estimates for the Equation (2.1) obtained by ordinary least squares (OLS). Column (2) shows the marginal effects of the explanatory factors associated with the decision to use multi-grade classes. The regressions stem from a panel of observations covering the 2017–2018 to 2022–2023 period. The symbols ***, *, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

4.2 Results from OLS and 2SLS

Table 3 presents two sets of results. The first set of results uses data from the 2022–2023 academic year, while the second relies on a panel of observations spanning the 2017–2018 to 2022–2023 period, excluding the 2019–2020 school year. All regressions incorporate a vector of seven explanatory variables related to academic achievement, comprising five socioeconomic indicators and two school-level variables, as described in Section 2.1[7]. The

[7] A reduction in class size may prove a factor that can benefit academic achievement (Angrist and Lavy, 1999; Krueger, 1999; Jackson and Page, 2013) or, conversely, cause zero significant effect (Hoxby, 2000; Leuven, Oosterbeek and Rønning, 2008). Sims (2008), Leuven and Rønning (2016), as well as Checchi and De Paola (2018), among others, have considered class size as a confounding factor in their analyses of the impact of MGCs on academic achievement. In the context of the present study, however, the statistics presented in Section 2 indicate that this factor isn't a concern. It varies little from one school to another and

models presented in columns (1) through (4) include school board fixed effects, thereby accounting for the potential influence of board-specific educational policies on average school performance. For validation purposes, column (5) instead reports estimates from a random effects model that introduces an unobserved school-specific component.

The estimated effects of the socioeconomic variables on the three indicators of academic achievement all display the expected signs. Except for the percentage of newly arrived students from non-English-speaking countries, all effects reach statistical significance at the 1% confidence level. Furthermore, public schools exhibit, on average, lower levels of academic success compared to Catholic schools, while English-language institutions perform less well than their French-language counterparts.

The final rows of Panels A, B, and C in Table 3 show that the number of third-grade students in multigrade classrooms causes a negative and statistically significant effect, regardless of the estimation method or model specification used. Moreover, the estimated coefficients exhibit minimal, if any, variation across OLS and 2SLS methods, across cross-sectional and panel data, or across alternative assumptions regarding unobserved effects.

Therefore, adding one more third-grade student to a multigrade classroom decreases the proportion of third-grade students meeting the provincial reading standard by 0.114 percentage points (Panel A, columns [1] and [2] of table 3). The estimated effect declines to -0.085 and -0.086 for the period 2017–2018 to 2022–2023 (Panel A, columns [3] and [4] of table 3). It further declines to -0.046 in the specification that accounts for school-specific unobserved effects (Panel A, column [5] of table 3). Comparable effects are observed for the proportions of students meeting provincial standards in writing (Panel B of table 3) and mathematics (Panel C of table 3).

tends to be at the regulatory threshold established with the aim of resource optimization. Finally, and most importantly, class size doesn't confound the discontinuity at the multiples of the maximum class size in Grade 3, as illustrated in Figure 1; a problem encountered by Leuven and Rønning (2016).

TABLE 3
OLS and IV regression results

	2022-2023		2017-2018 to 2022-2023		
	OLS	IV	OLS	IV-1	IV-2
	(1)	(2)	(3)	(4)	(5)
School board fixed effect	yes	yes	yes	yes	no
School random effect	no	no	no	no	yes
Year effect	no	no	yes	yes	yes
SEs adjusted for clustering					
- at the school level	no	no	yes	yes	no
- at the school board level	yes	yes	no	no	yes
Panel A : Grade 3 Students Achieving the Provincial Standard in Reading (%)					
Students receiving special educ.services (%)	-0.385***	-0.385***	-0.325***	-0.325***	-0.198***
	(0.067)	(0.066)	(0.029)	(0.029)	(0.030)
Gifted students (%)	0.570***	0.570***	0.206***	0.206***	0.259***
	(0.064)	(0.062)	(0.052)	(0.052)	(0.046)
School-Aged Children in Low-Income	-0.515***	-0.515***	-0.400***	-0.400***	-0.264***
Household (%)	(0.078)	(0.077)	(0.025)	(0.025)	(0.050)
Students Whose Parents Have No Diploma	-0.447***	-0.447***	-0.332***	-0.332***	-0.321***
	(0.081)	(0.079)	(0.039)	(0.039)	(0.039)
New students to Canada	0.059	0.059	0.033	0.033	0.083
from a Non-English speaking country (%)	(0.059)	(0.057)	(0.034)	(0.034)	(0.052)
Public schools (yes/no)	-13.155***	-13.154***	-23.460***	-23.462***	-3.673**
	(0.773)	(0.750)	(4.503)	(4.488)	(1.507)
English schools (yes/no)	-18.517***	-18.516***	-11.705***	-11.701***	-6.475***
	(0.336)	(0.340)	(3.556)	(3.545)	(2.513)
Grade 3 students in multi-grade classrooms	-0.114***	-0.114***	-0.085***	-0.086***	-0.046***
	(0.020)	(0.020)	(0.012)	(0.012)	(0.013)
Panel B : Grade 3 Students Achieving the Provincial Standard in Writing (%)					
Students receiving special educ.services (%)	-0.398***	-0.398***	-0.347***	-0.347***	-0.194***
	(0.075)	(0.073)	(0.035)	(0.035)	(0.037)
Gifted students (%)	0.510***	0.510***	0.199***	0.199***	0.282***
	(0.103)	(0.101)	(0.068)	(0.067)	(0.073)
School-Aged Children in Low-Income Hous (%)	-0.595***	-0.595***	-0.444***	-0.444***	-0.250***
	(0.090)	(0.088)	(0.030)	(0.030)	(0.084)
Students Whose Parents Have No Diploma	-0.542***	-0.542***	-0.298***	-0.298***	-0.307***
	(0.070)	(0.069)	(0.045)	(0.044)	(0.048)
New students to Canada	0.183***	0.183***	0.150***	0.150***	0.183***
from a Non-English speaking country (%)	(0.071)	(0.070)	(0.038)	(0.038)	(0.060)
Public schools (yes/no)	-19.430***	-19.430***	-28.672***	-28.672***	-5.647***
	(0.985)	(0.963)	(5.572)	(5.554)	(2.079)
English schools (yes/no)	-8.412***	-8.413***	-7.245	-7.245	0.636
	(0.414)	(0.410)	(4.813)	(4.798)	(3.592)
Grade 3 students in multi-grade classrooms	-0.152***	-0.152***	-0.116***	-0.116***	-0.056***
	(0.025)	(0.024)	(0.014)	(0.014)	(0.013)
Panel C : Grade 3 Students Achieving the Provincial Standard in Mathematics (%)					
Students receiving special educ.services (%)	-0.409***	-0.409***	-0.409***	-0.409***	-0.236***
	(0.081)	(0.080)	(0.034)	(0.034)	(0.035)
Gifted students (%)	0.630***	0.630***	0.328***	0.328***	0.323***
	(0.090)	(0.088)	(0.071)	(0.071)	(0.050)
School-Aged Children in Low-Income Hous (%)	-0.675***	-0.675***	-0.539***	-0.539***	-0.334***
	(0.092)	(0.090)	(0.029)	(0.029)	(0.046)
Students Whose Parents Have No Diploma	-0.564***	-0.564***	-0.338***	-0.338***	-0.307***
	(0.112)	(0.110)	(0.045)	(0.045)	(0.049)
New students to Canada	0.160***	0.160***	0.116***	0.116***	0.119**
from a Non-English speaking country (%)	(0.058)	(0.057)	(0.040)	(0.039)	(0.059)
Public schools (yes/no)	-18.295***	-18.289***	-21.769***	-21.771***	-1.629
	(0.977)	(0.956)	(4.981)	(4.965)	(1.690)
English schools (yes/no)	-14.416***	-14.393***	-15.740***	-15.737***	-10.259***
	(0.387)	(0.392)	(4.420)	(4.407)	(2.182)
Grade 3 students in multi-grade classrooms	-0.137***	-0.140***	-0.108***	-0.108***	-0.064***
	(0.025)	(0.026)	(0.013)	(0.014)	(0.017)
Number of schools	2 665	2 665	2 761	2 761	2 761
Observations	2 665	2 665	12 288	12 288	12 288
R-Squared	Between 0.303 and 0.322 depending on the model used				

NOTES: This table reports the estimates of the equation (2.2), obtained using Ordinary Least Squares (OLS) and Two-Stage Least Squares (2SLS) methods. The table provides two sets of estimates. The first relies solely on data from the 2022–2023 school year (columns [1] and [2]), while the second uses a panel of observations covering the period from 2017–2018 to 2022–2023 (columns [3] to [5]). The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

4.3 RDD findings

This section presents the results obtained using the regression discontinuity (RD) method. Section 4.3.1 begins with a graphical analysis of student achievement indicators for schools whose number of third-grade students lies close to the class size cap (20 students) or its multiples (40, 60). Section 4.3.2 examines a first set of estimates based on the standard RDD approach, using a constrained version of the Equation (3) and restricting the sample to schools that have an MGC. This approach makes it possible to estimate the localized average impact of MGCs for schools whose third-grade enrollment slightly exceeds the threshold corresponding to the class size cap or its multiples. A second set of estimates relies on the RD-DD method, as specified in Equation (3), in which schools without an MGC serve as the control group (Section 4.3.3). All regressions control for socioeconomic factors and for year effects and school board fixed effects in the case of panel data regressions.

4.3.1 Graphical analysis

Figure 2 showed that discontinuities in the number of students enrolled in multigrade classes emerge near the thresholds of 20, 40, and 60 third-grade students; levels of enrollment that correspond to the maximum class size limit or its multiples. We now seek to determine whether these observed discontinuities in the number of MGC students also generate discontinuities in the distribution of academic achievement rates.

Figure 3 illustrates the average rates of students meeting the provincial standard in reading, writing, and mathematics, by the number of third-grade students enrolled in each school. The figure concentrates on schools with 1 to 19 students in MGCs and whose third-grade enrollment falls between 15 and 24, 35 and 44, and 55 and 64. Panels (a) through (i) all display apparent discontinuities in achievement rates at the enrollment thresholds of 20, 40, and 60 students. Moreover, average achievement rates are generally higher in schools whose enrolment is slightly above these thresholds. It is worth noting that these schools have fewer students placed in multi-grade classes than those whose enrolment falls just below these thresholds.

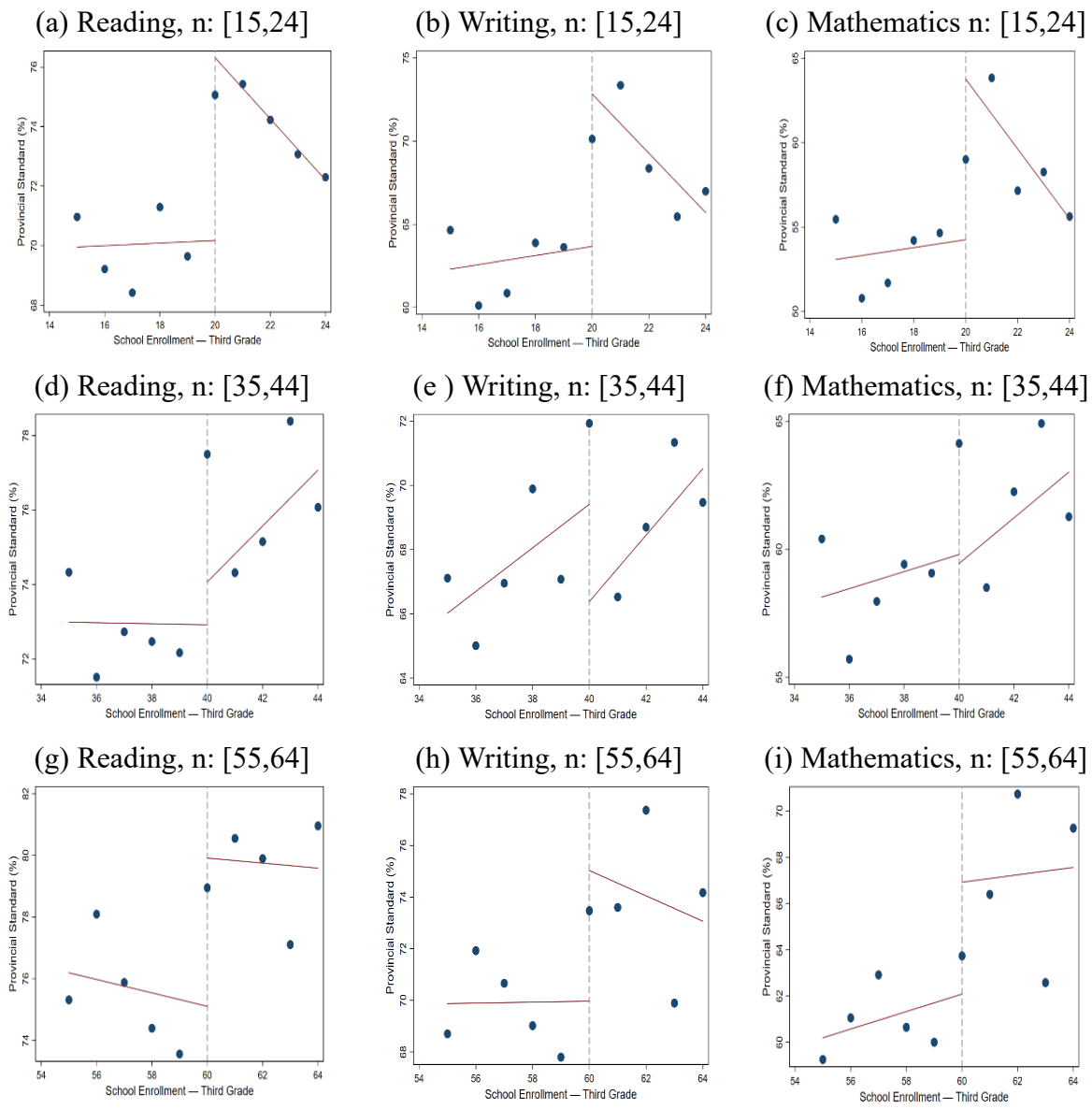

FIGURE 3 Average rate of Grade 3 students who meet the provincial standard in reading, writing, and mathematics in schools that have MGCs with 1 to 19 students.

NOTES: These graphs present the average rates of third-grade students meeting the provincial standard of academic achievement. The schools' enrollments fall within one of the following ranges: [15,24], [35,44], and [55,64], and their number of students enrolled in multi-grade classes ranges from 1 to 19. To facilitate the interpretation of the graphs, the percentages of students meeting the provincial standard in the three subject areas have been aggregated as an average for each enrollment level.

SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

The distribution of average achievement rates among schools with 20 to 39 students enrolled in multi-grade classes, and whose third-grade enrollment lies between 35 and 44 or 55 and 64, differs from that of the preceding group. As shown in Figure 4, no apparent discontinuity in average achievement rates is observed at the 40-student threshold for the 35–44 enrollment group (Panels a, b and c). By contrast, achievement rates tend to exceed those in schools with 55 to 59 students when they have 60 to 64 students (Panels d, e, and f). It's worth recalling that the number of students in multi-grade classes is greater for the [55, 59] group than for the [60, 64] group.

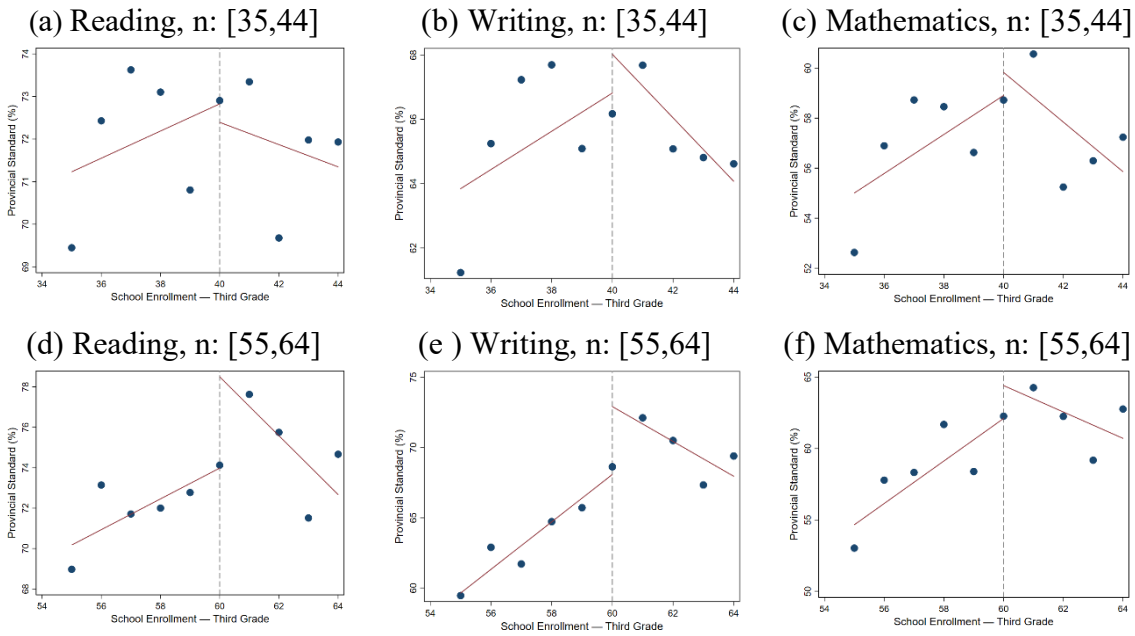

FIGURE 4 — Average proportion of third-grade students meeting the provincial standard in reading, writing, and mathematics in schools that have MGCs with 20 to 39 students.
NOTES: These graphs present the average rates of third-grade students meeting the provincial standard of academic achievement. The schools' enrollments fall within one of the following ranges: [35,44], and [55, 64]. Additionally, their number of students enrolled in multigrade classes ranges from 20 to 39. To facilitate the interpretation of the graphs, the percentages of students meeting the provincial standard in the three subject areas have been aggregated as an average for each enrollment level.
SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

Finally, the RD-DD method uses schools with no students enrolled in multi-grade classes as the control group. It's therefore useful to examine whether achievement rates display discontinuities around the thresholds of 20, 40, and 60 third-grade students for these schools without MGCs. Socioeconomic disparities could explain any significant differences in achievement rates, although these are accounted for in econometric regressions. They could also result from unobservable factors related to differences in school enrollment size or other unmeasured school-level phenomena.

Figure 5 shows a relatively uniform distribution of achievement rates for the groups of schools with [15, 23], [35, 44], and [55, 64] third-grade students, except for a few values that stand out on either side of the enrollment thresholds[8]. These observations suggest that differences in achievement rates associated with factors not accounted for in this study, on

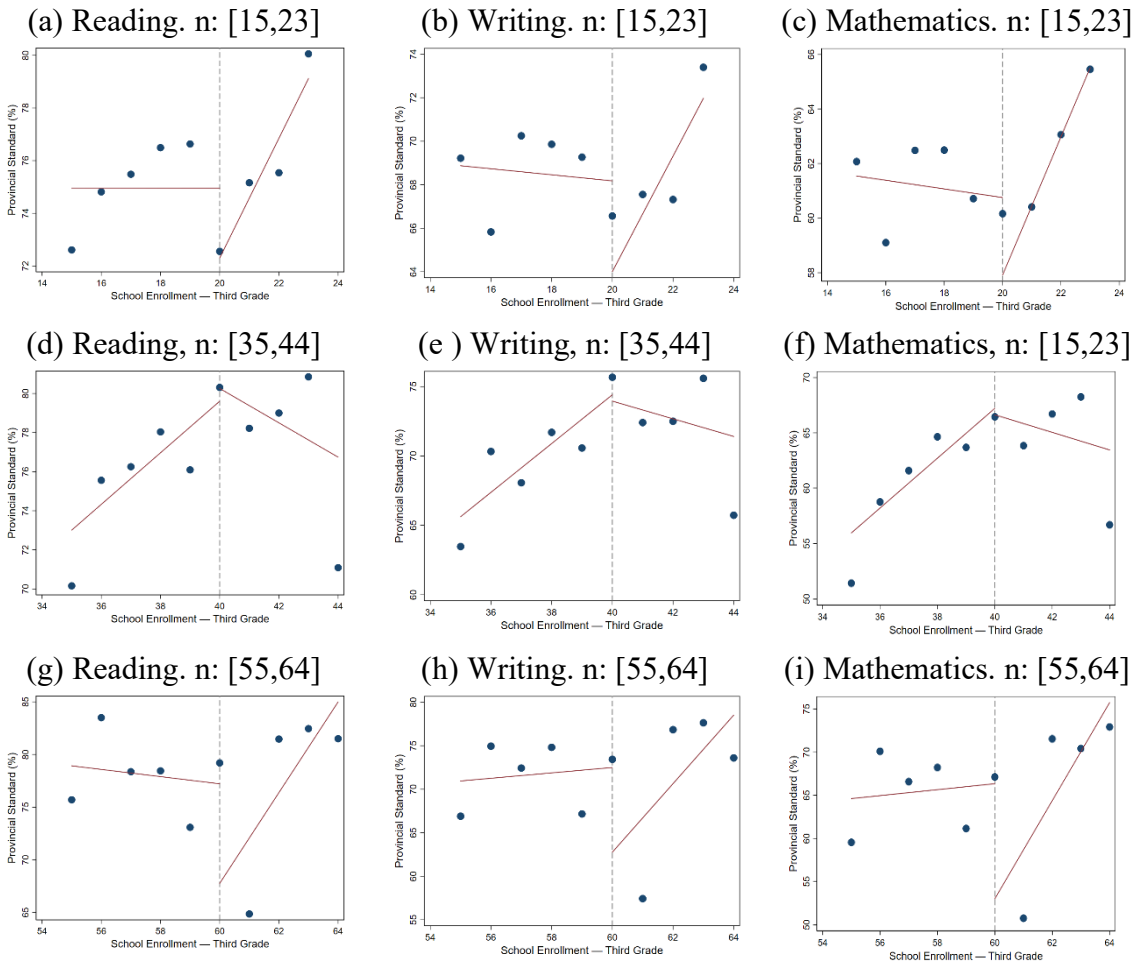

FIGURE 5 Average proportion of third-grade students meeting the provincial standard in reading, writing, and mathematics in schools without any MGCs.

NOTES: These graphs present the average rates of third-grade students meeting the provincial standard of academic achievement. They come from schools whose enrollments fall within one of the following ranges: [35, 44], and [55, 64], and without any students enrolled in multi-grade classes. To facilitate the interpretation of the graphs, the percentages of students meeting the provincial standard in the three subject areas have been aggregated as an average for each enrollment level.

SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

[8] The average achievement rate for the group of schools with 24 third-grade students doesn't appear, as it includes only one school characterized by an outlier observation.

either side of the enrollment thresholds, don't matter. The regression analyses presented in the next two sections will test the statistical significance of the differences in achievement rates between schools separated by the class size thresholds.

4.3.2 Standard RDD

Table 4 summarizes the results from the standard RDD analysis. Estimates are reported for three school enrollment groups: 15 to 25, 35 to 55, and 55 to 65 Grade 3 students. For each group, effects are estimated across one or more of the following MGCs enrollment ranges: 1 to 19, 20 to 39, and 40 to 59 students. Columns (1) to (3) present the results for the 2022–2023 school year, while columns (4) to (6) correspond to the period 2017–2018 to 2022–2023. All regressions include the explanatory variables described earlier.

Smaller MGCs tend to correspond to better reading achievement levels, as shown in Panel A of Table 4. However, only a few of these associations reach statistical significance. Specifically, for schools with 20 to 24 third-grade students, having fewer students in MGCs, approximately 1 to fewer than 10, increased the reading achievement standard by 3.370 percentage points in the 2022–2023 school year. This impact is estimated at 2.162 percentage points and is statistically significant over the period from 2017-2018 to 2022-2023.[9]

The estimates for schools with 35 to 44 and 55 to 64 third-grade students stand out, as they provide evidence on the impact of MGCs with larger numbers of participants. For schools with 40 to 44 students, column (2) of Table 4 suggests that having slightly more than 20 students in MGCs correlates with higher reading outcomes (+ 3.399 percentage points) compared to schools where this number is just below 40. Although this effect doesn't reach statistical significance in the panel data specification (column [5] of table 4), it does for the group of schools with 60–64 students. In this case, the average reading standard is estimated at 2.608 percentage points higher than that of schools with 55 to 59 third-grade students.

Comparable effects are observed for writing achievement standards, where fewer students in MGCs correlates to stronger academic outcomes (Panel B of Table 4). In schools with 20 to 24 third-grade students, having fewer students in MGCs than schools with 15 to 19 students increases writing performance. Its impact is estimated at 5.307 percentage points in 2022–2023 and 3.401 percentage points from 2017–2018 to 2022–2023. For 2022–2023, the differentiated effect amounts to 4.399 percentage points in

[9] This effect corresponds to the difference between the average achievement level of schools with 15 to 19 third-grade students (upper right section of quadrant 1 in Figure 2) and that of schools with 20 to 24 students (lower left section of quadrant 2 in Figure 2), after accounting for socioeconomic factors, year effects, and unobservable school board fixed effects. These estimates exclude schools without MGCs.

TABLE 4
Regression discontinuity results

Number of grade 3 students in MGC	2022-2023 [1,19]	2022-2023 [20,39]	2022-2023 [40,59]	2017-2018 to 2022-2023 [1,19]	2017-2018 to 2022-2023 [20,39]	2017-2018 to 2022-2023 [40,59]
	(1)	(2)	(3)	(4)	(5)	(6)
Year effect	no	no	no	yes	yes	yes
School board fixed effect	no	no	no	yes	yes	yes
The X variables are included in the regression	yes	yes	yes	yes	yes	yes
Panel A : Grade 3 Students Achieving the Provincial Standard in Reading (%)						
Number of grade 3 students : [15,24]						
20-student threshold indicator	3.370			2.162**		
	(2.371)			(0.955)		
Number of schools	208			1,188		
Number of grade 3 students : [35,44]						
40-student threshold indicator	1.906	3.399*		1.781*	0.208	
	(1.955)	(2.053)		(0.934)	(1.000)	
Number of schools	190	176		826	727	
Number of grade 3 students : [55,64]						
60-student threshold indicator	1.482	4.399*	13.171	2.126*	2.608**	-0.338
	(2.850)	(2.541)	(11.279)	(1.230)	(1.300)	(3.757)
Number of schools	96	93	18	370	361	85
Panel B : Grade 3 Students Achieving the Provincial Standard in writing (%)						
Number of grade 3 students : [15,24]						
20-student threshold indicator	5.307**			3.401***		
	(2.647)			(1.164)		
Number of grade 3 students : [35,44]						
40-student threshold indicator	2.252	4.913**		1.144	1.465	
	(2.473)	(2.482)		(1.101)	(1.170)	
Number of grade 3 students : [55,64]						
60-student threshold indicator	4.464	6.949**	12.498	2.559	5.518***	0.854
	(2.891)	(3.277)	(9.694)	(1.604)	(1.668)	(4.420)
Panel C : Grade 3 Students Achieving the Provincial Standard in mathematics (%)						
Number of grade 3 students : [15,24]						
20-student threshold indicator	4.501			2.729**		
	(2.800)			(1.153)		
Number of grade 3 students : [35,44]						
40-student threshold indicator	3.685	1.485		1.706	1.310	
	(2.373)	(2.239)		(1.145)	(1.150)	
Number of grade 3 students : [55,64]						
60-student threshold indicator	1.998	6.989**	9.067	3.672**	3.763***	-0.453
	(2.944)	(3.248)	(6.596)	(1.584)	(1.361)	(3.305)

NOTES This table reports estimates from standard regression discontinuity design, excluding schools without MGCs. Two sets of estimates are presented: the first relies solely on data from the 2022–2023 academic year (columns [1] to [3]), while the second uses a panel of observations spanning the 2017–2018 to 2022–2023 period (columns [4] to [6]). Observations were grouped according to three ranges of total school enrollment, [15,24], [35,44], and [55,64], and three ranges of MGC student counts, [1,19], [20,39], and [40,59], to exploit the discontinuities identified in Figure 2. Estimates were obtained using ordinary least squares regression for various combinations of these intervals. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

schools enrolling 40 to 44 third-grade students and slightly more than 20 students in MGCs (group [20,39]).

Table 4 further shows significant effects on schools with 60 to 64 third-grade students belonging to this same MGC group (columns [2] and [5] of table 4). Finally, Panel C of the table documents effects on mathematics achievement standards, again in favor of schools with relatively smaller MGC enrollments.

4.3.2 RD-DD results

We now analyze the results from the RD-DD regressions. This approach fits the context of this study well, as several schools don't have any multi-grade classes. The results are reported in Table 5. The binary variable *dGroupMGC [x, y]* identifies schools according to three enrollment ranges in multi-grade classes: [1,19], [20,39], and [40,59]. The coefficient associated with this variable estimates the gap in academic achievement between schools participating and not participating in multi-grade classes, while controlling for time effects, school board fixed effects, and socioeconomic characteristics.

The binary variables *dTreshold20*, *dTreshold40*, and *dTreshold60* take the value 1 when schools have more than 20, 40, and 60 third-grade students in the respective subgroups [15,24], [35,44], and [55,64]. Finally, the interaction between *dGroupMGC [x, y]* and *dTreshold`j'*, with j = 20, 40, or 60, makes it possible to estimate the effect of multi-grade classes for schools just above the discontinuity thresholds, while also accounting for unobservable factors associated with the control groups.

Section A.1 of Table 5 shows that multi-grade classes reduce reading achievement standards on average by 3.891 percentage points in schools with 15 to 24 third-grade students and 1 to 19 students in multi-grade classes (column [4] of table 5). Moreover, for the subgroup of schools with 20 to 24 students, the effect of multi-grade classes is estimated at 3.556 percentage points ($p < 0.05$). In other words, these schools, which have fewer third-grade students in multi-grade classes compared to the 15–19 student subgroup, achieve higher reading standards.

The effects estimated using the panel data approach for the groups of 35 to 44 students (see Section A.2 of Table 5) and 55 to 64 students (see Section A.3 of Table 5) compare favorably to the previous results. Except for the variable *dGroupMGC* [x, y], which alone exhibits statistically significant effects at the 1%, 5%, or 10% confidence levels. The estimated effects range from -2.028 to -6.558 percentage points, depending on the number of students in multi-grade classes. These results once again confirm that, on average, schools with multi-grade classes display lower reading achievement standards than other schools.

The estimates for writing and mathematics achievement standards corroborate the results presented previously. The analysis begins with the subgroup of schools with 15 to 24 third-grade students (see Sections B.1 and C.1 of Table 5). The coefficients associated with the binary variable *dGroupMGC [x, y]* are estimated at -5.134 ($p < 0.01$) and -4.832

($p < 0.01$) percentage points for writing and mathematics, respectively (see column [4] of table 5). Furthermore, the relatively low number of students in multi-grade classes in schools with 20 to 24 third-grade students positively affects achievement standards. This effect is estimated at 4.814 percentage points ($p < 0.05$) for writing and 3.730 percentage points ($p < 0.10$) for mathematics.

Negative and statistically significant effects of multi-grade classes on writing and mathematics achievement are also estimated for the subgroups of 35 to 44 and 55 to 64 third-grade students, independently of the three school groupings based on the number of students in multi-grade classes. For example, the estimated effects on writing standards for the 35 to 44 student group are -1.959 ($p < 0.10$) and -4.393 ($p < 0.01$) percentage points for the 1 to 19 and 20 to 39 student subgroups in multi-grade classes, respectively (see Section B.2 of Table 4, columns [4] and [5]). For mathematics, the corresponding effects are -0.857 and -2.750 ($p < 0.10$) percentage points (see Section C.2 of Table 4, columns [4] and [5]). Moreover, unlike the 15 to 24 student subgroups, schools with 40–44 or 60–64 students show no significant positive effects of multi-grade classes on academic achievement compared with subgroups below the 40- and 60-student thresholds.

TABLE 5
Regression discontinuity in Diffenrence-in-Differences results

Number of grade 3 students in MGC	2022-2023			2017-2018 to 2022-2023		
	[1,19]	[20,39]	[40,59]	[1,19]	[20,39]	[40,59]
	(1)	(2)	(3)	(4)	(5)	(6)
Year effect	no	no	no	yes	yes	yes
School board fixed effect	no	no	no	yes	yes	yes
X's included in the regression	yes	yes	yes	yes	yes	yes
Panel A : Grade 3 Students Achieving the Provincial Standard in Reading (%)						
A.1 Number of grade 3 students : [15,24]						
dGroupMGC[x,y]	-8.461***			-3.891***		
	(2.844)			(0.976)		
dTreshold20	-2.668			-1.420		
	(3.273)			(1.209)		
dGroupMGC[x,y] x dTreshold20	6.177			3.556**		
	(4.020)					
Number of schools	314			1,908		
A.2 Number of grade 3 students : [35,44]						
dGroupMGC[x,y]	-2.714	-7.080***		-2.028**	-2.852**	
	(2.207)	(2.676)		(0.961)	(1.171)	
dTreshold40	3.410	2.985		1.152	0.843	
	(2.489)	(2.508)		(1.220)	(1.197)	
dGroupMGC[x,y] x dTreshold40	-1.183	0.754		0.720	-0.627	
	(3.174)	(3.245)		(1.519)	(1.533)	
Number of schools	258	244				
A.3 Number of grade 3 students : [55,64]						
dGroupMGC[x,y]	3.370	-1.949	-3.567	-0.588	-3.786**	-6.558**
	(3.015)	(3.517)	(6.903)	(1.150)	(1.543)	(3.325)
dTreshold60	3.759	4.645	4.874	0.003	0.055	-0.227
	(3.258)	(3.288)	(3.222)	(1.582)	(1.584)	(1.680)
dGroupMGC[x,y] x dTreshold60	-3.012	-0.248	-3.171	1.988	2.258	1.367
	(4.349)	(4.079)	(8.546)	(1.968)	(2.052)	(3.467)
Number of schools	134	131	56	563	554	278
Panel B : Grade 3 Students Achieving the Provincial Standard in writing (%)						
B.1 Number of grade 3 students : [15,24]						
dGroupMGC[x,y]	-9.190**			-5.134***		
	(3.732)			(1.195)		
dTreshold20	-2.905			-1.333		
	(4.211)			(1.515)		
dGroupMGC[x,y] x dTreshold20	8.245			4.814**		
	(5.028)			(1.915)		
B.2 Number of grade 3 students : [35,44]						
dGroupMGC[x,y]	-4.822*	-9.622***		-1.959*	-4.393***	
	(2.593)	(3.248)		(1.135)	(1.402)	
dTreshold40	3.681	3.358		2.351*	1.647	
	(3.077)	(3.102)		(1.419)	(1.402)	
dGroupMGC[x,y] x dTreshold40	-1.009	1.674		-1.299	-0.127	
	(3.956)	(3.988)		(1.782)	(1.803)	
B.3 Number of grade 3 students : [55,64]						
dGroupMGC[x,y]	4.483	-3.116	-0.409	-0.928	-6.315***	-7.859**
	(3.397)	(4.116)	(8.401)	(1.343)	(1.834)	(3.749)
dTreshold60	3.932	6.127	5.559	-0.365	0.035	0.643
	(4.193)	(4.516)	(4.540)	(1.941)	(1.973)	(2.099)
dGroupMGC[x,y] x dTreshold60	0.097	0.804	-8.877	2.832	5.067**	1.825
	(5.110)	(5.590)	(10.410)	(2.441)	(2.542)	(4.092)
Panel C : Grade 3 Students Achieving the Provincial Standard in mathematics (%)						
C.1 Number of grade 3 students : [15,24]						
dGroupMGC[x,y]	-7.538**			-4.832***		
	(3.481)			(1.178)		
dTreshold20	0.196			-0.836		
	(3.845)			(1.509)		
dGroupMGC[x,y] x dTreshold20	4.417			3.730*		
	(4.796)			(1.913)		
C.2 Number of grade 3 students : [35,44]						
dGroupMGC[x,y]	0.622	-3.028		-0.857	-2.750*	
	(2.896)	(3.329)		(1.185)	(1.439)	
dTreshold40	5.881*	5.503		2.623*	2.137	
	(3.490)	(3.466)		(1.508)	(1.486)	
dGroupMGC[x,y] x dTreshold40	-2.136	-3.701		-0.990	-0.841	
	(4.189)	(4.130)		(1.881)	(1.866)	
C.3 Number of grade 3 students : [55,64]						
dGroupMGC[x,y]	1.704	-6.861*	-0.615	-2.255	-4.592***	-8.769***
	(2.776)	(3.523)	(5.620)	(1.397)	(1.632)	(3.352)
dTreshold60	2.344	2.284	2.405	0.937	1.495	2.168
	(3.270)	(3.134)	(3.363)	(1.897)	(1.913)	(1.941)
dGroupMGC[x,y] x dTreshold60	-0.857	4.722	-6.334	2.666	2.223	-1.468
	(4.531)	(4.550)	(7.131)	(2.392)	(2.327)	(3.489)

NOTES: This table reports estimates of regression discontinuity in difference-in-differences, including schools without MGCs. Two sets of estimates are presented: the first relies solely on data from the 2022–2023 academic year (columns [1]—[3]), while the second comes from a panel of observations spanning the 2017–2018 to 2022–2023 period (columns [4]—[6]). Observations were grouped according to three ranges of total school enrollment, [15,24], [35,44], and [55,64], and three ranges of MGC student counts, [1,19], [20,39], and [40,59], to exploit the discontinuities identified in Figure 2. Estimates were obtained by ordinary least squares regression for various combinations of these intervals. The symbols *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

SOURCE: Author's calculation is based on data from the Ontario Ministry of Education.

5. Conclusion

This study aims to estimate the impact of multi-grade classrooms on the academic achievement of third-grade students in the Canadian province of Ontario, using publicly available school-level data. Descriptive analysis reveals that, on average, the academic performance of third-grade students in schools with multi-grade classrooms lags behind that observed in schools that don't employ this class organization. Furthermore, the data indicate that the greater the number of third-grade students who share their class with second- or fourth-grade students, the lower the achievement levels tend to be.

Two methods were employed to robustly assess the impact of multi-grade classrooms on the three available indicators of academic achievement, namely, the percentages of third-grade students meeting the provincial standard in reading, writing, and mathematics. Each of these methods exploits the discontinuities in the number of students in multi-grade classes observed at the enrollment thresholds corresponding to the maximum class size or its multiples.

The first method draws from a 2SLS approach, in which the number of students in multi-grade classrooms serves as the variable of interest. To account for its potential endogeneity, this variable is instrumented using a prediction rule for the number of students in multi-grade classrooms, following approaches commonly used in the class-size literature. The second method relies on the regression discontinuity design, applied through two complementary approaches: the standard RDD and the difference-in-differences RDD.

The results obtained from these methods confirm the achievement gaps observed in the descriptive analysis: on average, multi-grade classrooms adversely affect the academic performance of third-grade students as a whole. More specifically, the instrumental variable estimation indicates a local average treatment effect of approximately -0.1. This means that an increase in one student in multigrade classrooms reduces, on average, the proportion of third-grade students meeting the provincial achievement standard by one tenth of a percentage point.

The regression discontinuity analyses also reveal the heterogeneity of effects across three ranges of student counts in multi-grade classrooms and according to the size of the third-grade cohorts. The standard regression discontinuity model estimates positive effects on academic achievement in schools with relatively few students in MGCs. For example, schools with 20 to 24 third-grade students and few students in MGCs see, on average, a 3.6 percentage point increase in the proportion of students meeting the provincial writing standard. This compares with schools with 15 to 19 third-grade students and nearly 19 students in MGCs. Similar patterns are observed for the other groupings, although only a few of the estimated effects are statistically significant.

The difference-in-differences regression discontinuity analysis confirms the adverse impact of multi-grade classrooms on the vast majority of schools that employ them, compared with schools without such classes. MGCs reduce by two to nine percentage points the proportion of their students meeting the provincial achievement standard. However, the effects appear more nuanced across the different groups of participating

schools. According to the estimates produced using the RD-DD method, schools with 20–24 third-grade students and few students at the same grade level in MGCs have significantly higher academic achievement. This is compared to schools with 15–19 third-grade students and a maximum number of students in multi-grade classrooms.

The results of this study, although limited by school-level aggregated data, nevertheless provide a robust perspective on the impact of multi-grade classrooms on academic achievement, considering both their direct and indirect effects on third-grade students in Ontario. These findings suggest two avenues regarding the evolution and optimization of this pedagogical organization:

1. The adoption of multi-grade classes should be approached with caution.
2. Particular attention should be given to instructional measures capable of mitigating or eliminating the adverse effects of multi-grade classes on academic achievement, prior to their implementation in schools.

References

Angrist, J. D., and Lavy, V. (1999). "Using Maimonides' rule to estimate the effect of class size on scholastic achievement," *The Quarterly Journal of Economics,* May 1991, pp. 533–575.

Angrist, J. D., V., Leder-Luis, J, and Shany, A. (2019). "Maimonides' rule redux," *American Economic Review: Insights,* Vol. 1, pp. 309–324.

Barbetta, G. P., Chuard-Keller, P., Sorrenti, G., and Turati, G. (2023). "Good or bad? Understanding the effects over time of multigrading on child achievement," *Economics of Education Review,* vol. 96, pp. 1–7.

Borbely, D., M. Gehrsitz, S. McIntyre, G. Rossi and G. Roy (2023). "Early Years Multi-grade Classes and Pupil Attainment," *Oxford Bulletin of Economics and Statistics,* vol. 85, 6, pp. 1295–1319.

Boucher, V., Bramoullé, Y., Djebbari, H. and Fortin, B. (2012). "Do Peers affect Student Achievement? Evidence from Canada Group Size Variation," *Journal of Applied Econometrics,* Vol. 29, 1, pp. 91–109.

Burns, R. B. and Mason, D. W. (2002). "Class Composition and Student Achievement in Elementary Schools," *American Educational Research Journal,* vol. 39, 1, pp. 207–233.

Carman, K. G. and Zhang, L. (2012). "Classroom peer effects and academic achievement: Evidence from a Chinese middle school," *China Economic Review,* Vol. 23, 2, pp. 223–237.

Checchi D, De Paola, M. (2018). "The effect of multigrade classes on cognitive and noncognitive skills. Causal evidence exploiting minimum class-size rules in Italy," *Economics of Education Review,* Vol. 67, pp. 235–253.

Ewijk, R. V. and Sleegers, P. (2010). "The effect of peer socioeconomic status on student achievement: A meta-analysis," *Educational Research Review,* vol. 5, 2, pp. 134–150.

Gottfried, M. A. (2012). "Peer Effects in Urban Schools: Assessing the Impact of Classroom Composition on Student Achievement," *Educational Policy,* vol. 28, 5, pp. 607–647.

Grembi, V., Nannicini, T. and Troiano, U. (2016). "Do Fiscal Rules Matter?," *American Economic Journal: Applied Economics,* vol. 8, 3, pp. 1–30. http://dx.doi.org/10.1257/app.20150076.

Haeck, C., Lacroix, G. and Santarossa, G. (2022). *The effects of grade retention on student achievement in Quebec: An econometric assessment*. Unpublished working paper. Department of Economics, UQAM; Department of Economics, Université Laval; Centre for Information and Research in Economics and Evaluation (CIREE). Report prepared for the Quebec Ministry of Education.

Hoxby, C. M. (2000). "The Effect of Class Size on Student Achievement: New Evidence from Population Variation," *The Quarterly Journal of Economics,* Vol. 115, 4, pp. 1239–1285.

Hyry-Beihammer, E.K. et Hascher, T. (2015). "Multi-grade teaching practices in Austrian and Finnish primary schools". *International Journal of Educational Research,* vol. 74, pp. 104-113.

Krueger, A.B. (1999). "Experimental Estimates of Education Production Functions". *The Quarterly Journal of Economics,* vol. 144, 2, pp. 497-532.

Jackson, E. et Page, M. E. (2013). "Estimating the distributional effects of education reforms: a look at Project STAT," *Economics of Education Review,* vol. 32, pp. 92–103.

Lataille-Démoré, D. (2007). "Combined Grade Classrooms, *What Works?" Research Into Practice,* Research Monograph #9, The Literacy and Numeracy Secretariat.

Lataille-Démoré, D. (2008). "Which Practices Optimize Learning in a Combined Grade Class?" *McGill Journal of Education,* Vol. 43, 3, pp. 351–369. https://doi.org/10.7202/029703ar.

Leuven, E. and Rønning, M. (2016). "Classroom grade composition and pupil achievement," *The Economic Journal,* Vol. 126, 593, pp. 1164–1192.

Leuven, E., Oosterbeek, H. and Rønning, M. (2008). "Quasi-experimental Estimates of the Effect of Class Size on Achievement in Norway," *Scand. J. of Economics, vol. 110, no. 4, pp. 663–693.*

Lloyd, L. (1999). "Multi-Age Classes and High Ability Students," *Review of Educational Research,* Vol. 69, 2, pp. 187–212.

Ministry of Education of Ontario (2025). Data Catalogue. Ontario.

Mulryan-Kyne, C. (2007). "The preparation of teachers for multigrade teaching," *Teaching and Teacher Education,* vol. 23, 4, pp. 501-514.

Quail, A. and Smyth, S. (2014). "Multigrade teaching and age composition of the class: The influence on academic and social outcomes among students," *Teaching and Teacher Education,* Vol. 43, pp.80-90. http://dx.doi.org/10.1016/j.tate.2014.06.004.

Sims, D. (2008). "A Strategic Response to Class Size Reduction: Combination Classes and Student Achievement in California". *Journal of Policy Analysis and Management, Vol. 27, 3, pp. 457-478.*

Takahashi, M. (2025). "A Note on Identification of the Difference-in-Discontinuities Design," Unpublished. Available at SSRN: https://ssrn.com/abstract=4686891.

Thomas, J.L. (2012). "Combination classes and educational achievement," *Economics of Education Review,* Vol. 31, pp.1058-1066.

Veenman, S. (1995). "Cognitive and noncognitive effects of multigrade and multi-age classes: A best-evidence synthesis," *Review of Educational Research,* vol. 65, pp. 319-381.

Veenman, S. (1996). "Effects of Multigrade and Multi-age Classes Reconsidered," *Review of Educational Research,* vol. 66, 3, pp. 323-340.