

The Impact of Multigrade Classes on the Academic Achievement of Grade 3 Students in Ontario Elementary Schools

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Abstract

Objective Multi-grade classrooms constitute a pedagogical approach in which students from different grade levels are taught together in the same classroom. In a context where the effects of this educational practice remain poorly documented in Canada, the present study aims to assess the impact of the number of Grade 3 students enrolled in multi-grade classrooms on the academic achievement rates of Grade 3 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 (RDD), directly exploits these discontinuities in the distribution of students across multi-grade classes.

Results The results obtained using these methods indicate that multi-grade classrooms have an adverse effect on achievement rates in reading, writing, and mathematics. Moreover, the magnitude of these negative effects increases with the number of Grade 3 students who share their learning environment with students from adjacent grade levels.

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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 variable 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-Belhammer 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 Slegers, 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 this end, I adopt a treatment-effect framework, following Sims (2008), using school-level aggregated data on achievement rates as well as school-level and socioeconomic characteristics, and classroom-level data on the number of Grade 3 students enrolled in multi-grade classrooms. The discontinuities observed in the number of students enrolled in multi-grade classrooms at the regulatory threshold for Grade 3 class size, or at its multiples, allow for the application of an instrumental variables approach, following Angrist and Lavy (1999), in which the instrument is, in the present case, a predictive rule for the expected number of students enrolled in multi-grade classrooms. Finally, these discontinuities are also exploited using a regression discontinuity design.

The use of school-level aggregated data makes it possible to capture not only the direct effects of multi-grade classrooms on the performance of students enrolled in these classrooms, but also their indirect effects on the overall functioning of the school. Indeed, the presence of multi-grade classrooms may influence student allocation, collective teaching practices, and school climate, among other dimensions that may affect the average academic achievement of students in the school (Checchi and DePaola, 2018). However, this aggregate approach does not allow the respective contributions of direct and indirect effects to be empirically disentangled, thereby limiting the precision with which the estimated effect can be interpreted. It is also important to emphasize that this effect should be interpreted as a school-level policy-intensity effect of multi-grade classrooms, rather than as an individual-level effect of multi-grade classrooms on students.

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 contains 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 observations². This panel structure makes it possible to control fixed and unobservable confounding factors at the school board level, and for year effects.

² 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 fewer³. 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).

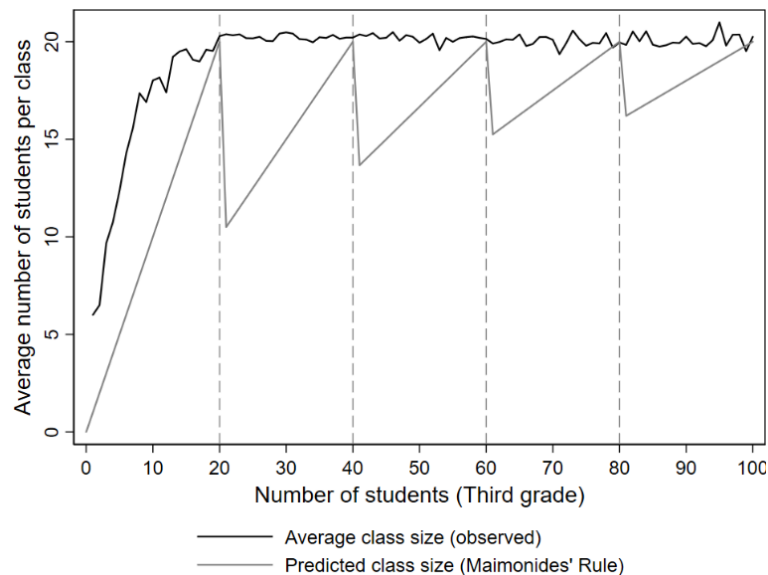


FIGURE 1 Observed and Predicted Average Class Size for Grade 3 Students (Maimonides' Rule), Ontario Schools, 2022–2023.

SOURCE: Author's calculation 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.

³ 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 reasons⁴. 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 3⁵. 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.

Furthermore, in schools that make use of multi-grade classrooms (MGCs), the number of Grade 3 students assigned to such classrooms varies not only as a function of overall enrollment and the thresholds associated with prescribed class-size regulations, but also according to other school-specific organizational considerations. Thus, among schools with fewer than 20 Grade 3 students (Quadrant 1 of Figure 2), two main configurations are observed: either no multi-grade classroom is formed, or all Grade 3 students are assigned to a multi-grade classroom. In this scenario, a school with 10 Grade 3 students who are combined with one or more students from another grade level will have all 10 Grade 3 students in a mixed-grade classroom.

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 a 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 (e.g., 20 students), which leads to the formation of an additional multi-grade grouping.

⁴ Figure 2 was partitioned into 24 quadrants to facilitate interpretation. The vertical lines correspond to the regulatory class-size threshold of 20 students and its multiples. The horizontal lines delineate the intervals of MGCs enrollment used in the econometric analyses.

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

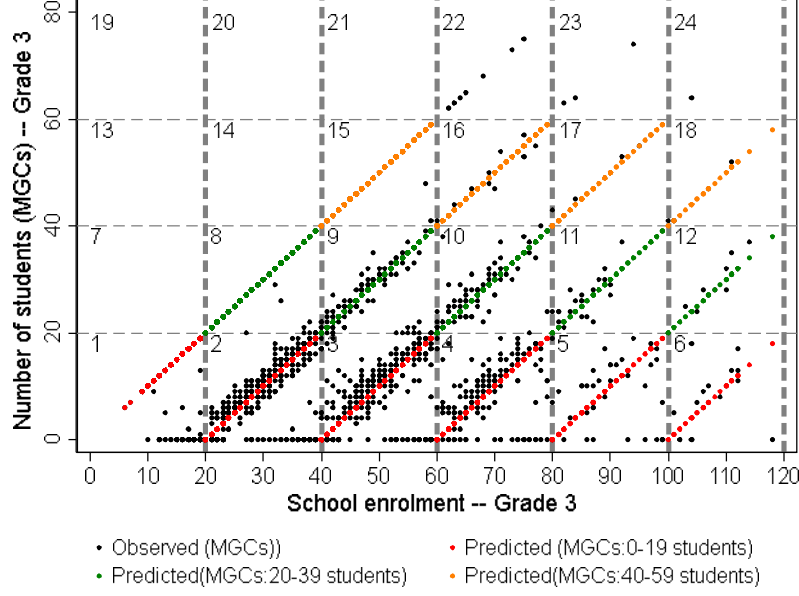


FIGURE 2 Observed and Predicted Number of Grade 3 Students in Multigrade Classes, Ontario Primary Schools, 2022–2023.

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 (see equation [1]). 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 based on data from the Ontario Ministry of Education.

Following some logic similar to that underlying Maimonides’ rule, the number of students assigned to MGCs is instrumented by the predicted number of students in such classrooms. This prediction is derived from a mathematical rule based on school enrollment and the regulatory class-size threshold. The variation in MGC assignments induced by this rule provides the source of identification used to estimate the causal effect of multi-grade classrooms on student academic achievement.

Let n_i denotes 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:

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

where K_i denotes the number of Grade 3 students observed in the MGCs of school i . In this equation, the function $\text{int}(x)$ represents the floor of x , that is, the greatest integer less than

or equal to x . 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)⁶. $j = 20$ 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.

As discussed below, the predicted number of students in MGCs, computed separately for each of the four strata described above, is used as an instrumental variable in the first stage of the two-stage least squares (2SLS) regressions estimated separately within each stratum. Under this approach, causal identification of the effect of MGCs relies primarily on the exogenous variation generated by the prediction rule and on the discontinuities in the predicted number of students at the threshold corresponding to the maximum Grade 3 class size and its multiples. Combined with observable control variables, including the proportion of students with learning difficulties in each school, this estimation strategy is designed to provide a credible estimate of the causal effect of MGCs on academic achievement.

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 MGCs⁷. 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 non-English-

⁶ For the group of schools with 0 to 19 students enrolled in multi-grade classrooms, the predictions generated by the mathematical rule primarily concern schools with students enrolled in multi-grade classrooms when Grade 3 enrollment differs from the regulatory class-size threshold or its multiples. In this context, schools without multi-grade classrooms are excluded from the instrumental variables estimates, since the identification strategy relies primarily on variations in the number of students enrolled in multi-grade classrooms induced by the discontinuities generated by this rule.

⁷ 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%).

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.

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 classrooms⁸. These findings 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

⁸ 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.

of third-grade students in MGCs share their class with older, fourth-grade students (53.0%) than with younger, second-grade students (46.7%).

Table 1—Comparative statistics

Variable	MGCs (N)			MGCs (N)		MGCs (N)	
	0 (1)	[1,19] (2)	(2)-(1) (3)	[20,39] (4)	(4)-(2) (5)	[40,59] (6)	(6)-(4) (7)
Numbre of 3rd grade students : 20 <= N < 100							
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 from non-English-speaking countries	4.9	6.0	1.1 *	6.0	0.1	6.0	0.0
Newly arrived students from non-French-speaking countries	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	0.1 *
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	0.0 *
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	0.1 *
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 for the year 2022–2023.

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

2.3 Graphical analysis

Figure 2 shows that the number of Grade 3 students enrolled in MGCs exhibits clear discontinuities at the thresholds of 20, 40, and 60 Grade 3 students, which correspond to the regulatory maximum class size or its multiples. As a first step in assessing the impact of MGCs on academic achievement, it is therefore informative to examine whether these thresholds, which generate discontinuous changes in the number of students enrolled in MGCs, also give rise to discontinuities in academic achievement rates. This analysis thus makes it possible to assess whether the changes in the number of students enrolled in MGCs induced by the regulatory rule lead to corresponding changes in academic outcomes.

Figure 3 illustrates the average rates of Grade 3 students meeting the provincial standard in reading as a function of the number of Grade 3 students enrolled in schools. The attention is directed towards institutions with a student count of 1 to 19 in Grade 3 participating in MGCs. First, achievement rates appear to increase with the number of Grade 3 students enrolled in the school, as school size may be correlated with characteristics that are conducive to academic achievement. However, the apparent discontinuities in achievement rates at the school-enrollment thresholds of 20, 40, and 60 students are particularly noteworthy: average achievement rates are markedly higher in schools whose enrollment lies just above these thresholds. It is important to note that these schools have fewer students enrolled in MGCs than schools whose enrollment lies just below these thresholds.

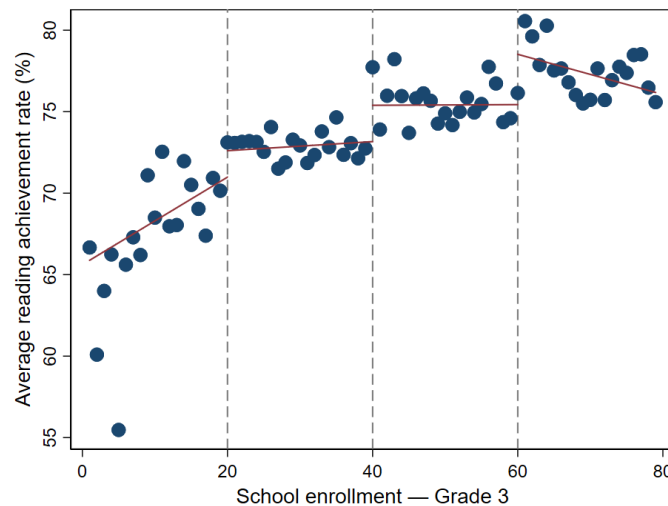


FIGURE 3 Average rate of Grade 3 students who meet the provincial standard in reading and have MGCs of 1 to 19 students.

NOTES: This figure illustrates the average reading achievement rates of Grade 3 students as a function of the number of Grade 3 students enrolled in schools. It applies to schools with 1 to 19 Grade 3 students enrolled in MGCs. For each enrollment level, the average achievement rate is calculated as the mean percentage of students meeting the provincial standard in reading across the corresponding schools.

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

The relationship between average achievement rates and school enrollment for the group of schools with 20–39 students enrolled in multigrade classes, as presented in the following figure, differs slightly from that observed for the previous group. Specifically, no apparent discontinuity in average achievement rates is observed at the 40-student threshold. Conversely, the average achievement rates tend to be higher among the 60 or more students enrolled in Grade 3. It is worth noting that the number of students enrolled in MGCs is higher, for example, in schools with 55–59 Grade 3 students than in those with 60–64 Grade 3 students.

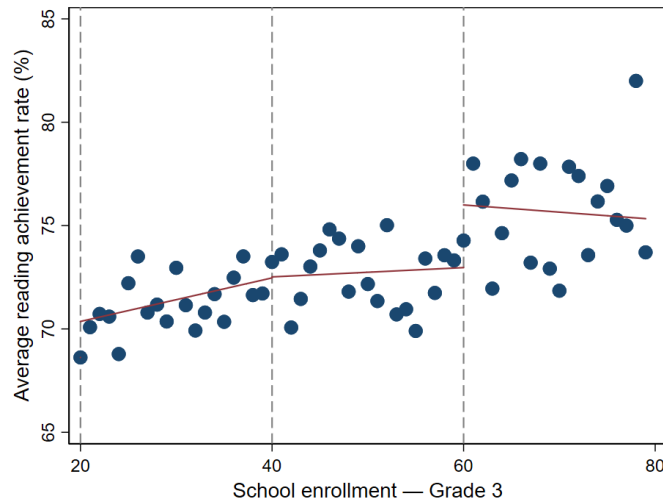


FIGURE 4 — The average rate of grade 3 students who meet the provincial standard in reading with MGCs of 20 to 39 students.

NOTES: This figure illustrates the average reading achievement rates of Grade 3 students as a function of the number of Grade 3 students enrolled in schools. It covers schools with 20 to 39 Grade 3 students enrolled in MGCs. For each enrollment level, the average achievement rate is calculated as the mean percentage of students meeting the provincial standard in reading across the corresponding schools.

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

Finally, Figure 5 presents the average reading achievement rates for the group of schools with no students enrolled in MGCs. Unlike the preceding figures, no apparent discontinuities in achievement rates are observed at the thresholds of 20, 40, and 60 Grade 3 students. This absence of discontinuities among schools without MGCs is consistent with the hypothesis that the discontinuities observed in Figures 3 and 4 are attributable to changes in the number of students enrolled in MGCs induced by crossing the school-enrollment thresholds. The regression analyses presented in the following two sections will assess the statistical significance of the relationship between achievement rates and the number of students enrolled in MGCs within schools.

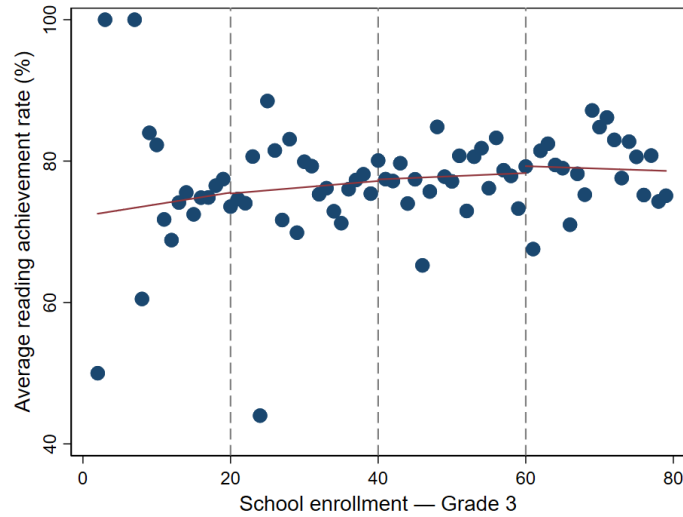


FIGURE 5 Average rate of Grade 3 students who meet the provincial standard in reading and have no MGCs.

NOTES: This figure illustrates the average reading achievement rates of Grade 3 students as a function of the number of Grade 3 students enrolled in schools. It covers schools with no MGCs. For each enrollment level, the average achievement rate is calculated as the mean percentage of students meeting the provincial standard in reading across the corresponding schools.

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

3 Methodology

The objective of this study is to estimate the effects of MGCs on academic achievement using school-level data. Rather than relying on a binary indicator of school participation, the analysis focuses on the intensity of exposure to this educational arrangement, measured by the number of students enrolled in MGCs within each school. The parameter of interest is therefore a policy-intensity treatment effect, defined as the effect associated with a change in the intensity of Grade 3 students’ exposure to this form of school organization.

This analysis is conducted in a context where schools’ adoption of MGCs is driven primarily by considerations related to class-size constraints and the efficient allocation of students across classes, maximizing class size efficiency, as illustrated in Figure 1. Nevertheless, both the decision to adopt MGCs and the allocation of students to them may also depend on observable and unobservable characteristics, such as age, socio-emotional maturity, or the severity of learning difficulties. These factors may act as confounders in the estimation of the effects of MGCs on academic achievement (Borbely et al., 2023).

To credibly estimate the impact of MGCs on the academic achievement of Grade 3 students, we first rely on an instrumental variable approach similar to that employed by Angrist and Lavy (1999), as well as by Angrist, Leder-Luis, and Shany (2019) in their

analyses of class-size effects. The instrument used in this study is the predicted number of Grade 3 students assigned to MGCs as a function of Grade 3 enrollment, according to the prediction rule defined in Equation (1). Figure 2 shows that this rule closely predicts the number of students assigned to MGCs and reproduces the observed discontinuities in MGC enrollment. These discontinuities provide an exogenous source of variation that serves to identify the causal impact of MGCs.

Furthermore, the prediction rule is implemented separately within the intervals [0,19], [20,39] and [40,59] of Grade 3 enrollment in MGCs, leading to separate estimates of the effect of MGCs on each stratum. This approach fully exploits the exogenous variation induced by the discontinuities at the regulatory class-size threshold and its multiples. It also allows for the investigation of treatment-effect heterogeneity across strata defined by the number of students enrolled in MGCs, a measure that reflects varying intensities of exposure to multi-grade schooling.

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

$$M_{it} = \delta M_{it}^p + \pi X_{it} + \tau_t + \theta_j + \varepsilon_{it}, \quad (2.1)$$

$$Y_{it} = \theta \widehat{M}_{it} + \beta X_{it} + \alpha_t + \gamma_j + u_{it}, \quad (2.2)$$

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). 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 θ_j and γ_j capture school boards fixed effects. The components ε_{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 prediction rule for MGCs, particularly in cases where schools don't implement multi-grade classes.

The estimation of the impact of multi-grade classrooms subsequently relies, following the approach of Angrist and Lavy (1999), on a regression discontinuity (RD) design applied to observations located near the thresholds of 20, 40, and 60 Grade 3 students. As noted above, the discontinuities observed in the number of students enrolled in multi-grade classrooms at these thresholds arise in part from Ontario's school regulations, which essentially limit Grade 3 class size to 20 students per class.

The sharp RD design relies on the assumption that the selection variable, in this case school enrollment, is the sole determinant of the discontinuities observed in the number of Grade 3 students enrolled in multi-grade classrooms. These discontinuities are implicitly exploited to estimate the effect of multi-grade classrooms on academic achievement. Other confounding factors, whether observed or unobserved, are assumed not to influence the discontinuities in the number of students enrolled in multi-grade classrooms. In the present context, however, this assumption appears difficult to sustain because, as shown in Figure 2, schools may choose different numbers of Grade 3 students to enroll in MGCs for the same overall enrollment, particularly near the discontinuity thresholds. These choices may plausibly be influenced by factors other than school enrollment. Within this analytical framework, the estimated treatment parameter corresponds to a local average treatment effect.

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

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

In this equation, the binary variable d_T identifies one of the three third-grade enrollment thresholds that generate discontinuity 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 this particular context of the RD regression, schools without MGCs are excluded from the estimation. Consequently, the parameter γ represents the local average treatment effect of MGCs for the group of schools with 40 to 44 third-grade students that offer MGCs, conditional on 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).

4. Results

This section presents the results of the study. The analysis begins with an examination of the factors that, based on the available information, lead schools, first, to include MGCs within their institutions and, second, to determine the number of students in these classes (Section 4.1). It then proceeds with an evaluation of the impact of MGCs using the ordinary least squares (OLS) and two-stage least squares (2SLS) methods (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

Beyond schools that exclude multi-grade classes (MGCs) from their pedagogical organization, Figure 2 shows that the number of students in MGCs increases linearly with total school enrollment, with discontinuities at thresholds corresponding to the maximum class size or its multiples. This pattern is consistent with schools maximizing class size in order to optimize the use of teaching resources.

In addition, Section 2 illustrates the variability among schools in the number of Grade 3 students assigned to MGCs based on total enrollment. Some schools prefer a minimal number of students in MGCs, while others opt for an intermediate level, and still others choose a maximal level. As noted, these configurations reflect a decision-making process by school staff, potentially based on students' socio-emotional development, their specific educational needs, and the compatibility of students within classes.

This section analyzes the impact of available socioeconomic characteristics on the number of students in multi-grade classes (MGCs), as well as on various groupings of these students. This exercise aims, on the one hand, to empirically identify the determinants of MGCs using information provided by school districts and, on the other hand, to partially assess the validity of the instrumental variables approach through an examination of the first-stage equation in the two-stage least squares estimation.

Table 2 reports the results of a regression of the number of students in MGCs on a set of socioeconomic variables as well as Grade 3 enrollment. Column (1) presents estimates obtained using the full set of observations, including schools with and without MGCs. The results indicate that the percentage of students receiving special education services, as well as the public status of schools, are associated with an increase in the number of Grade 3 students enrolled in MGCs. In addition, the increase in the number of students in MGCs, as illustrated in Figure 2, is also associated with rising Grade 3 enrollment in schools.

Columns (2) – (4) of Table 2 present estimates of the equation (2.1) for three MGC enrollment subgroups: 1–19, 20–39, and 40–59 students. In these specifications, the share of students with special educational needs is also among the variables whose effect on MGC enrollment is not statistically significant at the 1% level, along with public school status. As shown below, these school and socioeconomic characteristics may nonetheless affect student grouping decisions in MGCs independently of Grade 3 enrollment.

Moreover, the instrument employed to predict MGC enrollment, as defined in equation (1), is statistically significant ($p < 0.01$) across all first-stage regressions. The F-statistic reported in Table 2 further indicates that the instrument is highly relevant, providing substantial explanatory power for the endogenous variable, whereas the remaining socioeconomic covariates are not statistically significant.

TABLE 2
Number of students in MGCs: OLS regression results

Number of Grade 3 students in MGCs	All	1 to 19	20 to 39	40 to 59
	(1)	(2)	(3)	(4)
<i>Explanatory variables</i>				
Students receiving special educ.services (%)	0.039*** (0.013)	-0.007* (0.004)	-0.007 (0.006)	0.014 (0.026)
Gifted students (%)	0.034 (0.025)	0.014* (0.008)	0.007 (0.009)	0.034 (0.070)
School-Aged Children in Low-Income Household (%)	0.005 (0.011)	-0.001 (0.004)	0.002 (0.005)	-0.020 (0.018)
Students Whose Parents Have No Diploma	0.015 (0.014)	0.004 (0.004)	0.002 (0.006)	0.006 (0.025)
New students from a Non-English speaking country (%)	-0.001 (0.016)	0.005 (0.006)	-0.000 (0.008)	-0.030 (0.026)
Public schools (yes/no)	3.254*** (0.203)	0.052 (0.067)	0.259** (0.115)	0.579 (0.564)
Grade 3 enrollment	0.117*** (0.006)	0.013*** (0.002)	0.001 (0.003)	0.006 (0.010)
Instrument: Predicted MGC enrollment		0.726*** (0.009)	0.711*** (0.016)	0.756*** (0.046)
Number of schools				
N	14,415	7,388	4,622	523
F-statistic	82.5	674.9	178.5	34.7
R ²	0.071	0.652	0.583	0.678

NOTES: This table reports, in column (1), the estimates of the regression of the number of students in MGCs on socioeconomic variables using the full sample. Columns (2) to (4) present the estimates of the equation (2.1) for three subgroups of students in MGCs: 1–19 students, 20–39 students, and 40–59 students. 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 based on data from the Ontario Ministry of Education.

A more comprehensive analysis of the data nevertheless suggests that socioeconomic factors may help explain the number of students in MGCs. Figure 2 highlights distinct clusters of schools for a given level of student enrollment. Thus, although the number of students in MGCs naturally increases with school size, questions remain regarding the determinants of the differentiated MGC configurations observed for a given number of third-grade students.

Section 2 outlined the process by which students are assigned to MGCs based on their abilities, maturity, or learning difficulties, as described by certain school districts in Ontario. Data limitations at the school level, however, restrict the capacity to account for the influence of these factors on MGC enrollment. Nevertheless, multinomial logit regression results show that specific explanatory variable, most notably the percentage of

students receiving special education services, significantly affect the probability that a school adopts a configuration with a higher or lower number of students in MGCs, regardless of overall grade 3 enrollment.

Table 3 reports the estimates of multinomial logit models in which the polytomous dependent variable takes values 0, 1, 2, or 3, corresponding respectively to the following categories of students in MGCs: 0, [1–19], [20–39], and [40–59]. The estimates are computed separately for three ranges of third-grade school enrollment: [20–24], [40–44], and [60–64]⁹. The results indicate that the proportion of students with learning difficulties in a school is associated with the type of grouping observed in MGCs. Specifically, an increase in this proportion raises the probability, for schools with third-grade enrollments between 20 and 24 or 40 and 44 students, of having MGCs in which a relatively high number of third-grade students (20–39) are grouped with second- or fourth-grade students. Conversely, for schools with 40–44 third-grade students, a higher proportion of students with learning difficulties decreases the likelihood of observing MGCs in which a small number of third-grade students (1–19) are grouped with other grade levels.

Furthermore, a higher percentage of students identified as gifted in schools with 20–24 third-grade students is associated with a lower likelihood of employing a multi-grade class. This variable is also linked to a reduced probability of observing MGCs with a small number of third-grade students. Similarly, the proportion of students from low-income households influences the type of grouping adopted, affecting the likelihood of different MGC configurations. Finally, public schools are more likely to establish MGCs that include a substantial proportion of third-grade students.

⁹ These ranges of school enrollment account for the possibility of assigning a small number of third-grade students to MGCs.

TABLE 3
Multinomial logit regression results

Number of Grade 3 students in MGCs	Marginal effects			
	0	1 to 19	20 to 39	40 to 59
Grade 3 enrollment : 20-24				
Students receiving special educ.services (%)	-0.002*	-0.002	0.004***	
Gifted students (%)	0.005***	-0.008**	0.003	
School-Aged Children in Low-Income Household (%)	-0.003**	0.004***	-0.001	
Students Whose Parents Have No Diploma	-0.001	-0.001	0.002	
New students from a Non-English speaking country (%)	0.000	-0.002	0.002	
Public schools (yes/no)	-0.039*	-0.063***	0.102***	
Grade 3 enrollment : 40-44				
Students receiving special educ.services (%)	-0.002	-0.006**	0.008***	-0.001
Gifted students (%)	0.002	-0.002	0.003	-0.004
School-Aged Children in Low-Income Household (%)	-0.001	0.001	-0.004**	0.003***
Students Whose Parents Have No Diploma	-0.003	-0.001	0.004*	-0.001
New students from a Non-English speaking country (%)	-0.000	-0.001	0.003	-0.002
Public schools (yes/no)	-0.074***	-0.079***	0.031	0.122***
Grade 3 enrollment : 60-64				
Students receiving special educ.services (%)	-0.001	0.001	-0.001	0.001
Gifted students (%)	-0.004	0.008	0.007	-0.011
School-Aged Children in Low-Income Household (%)	0.001	-0.000	-0.004	0.003
Students Whose Parents Have No Diploma	-0.004	0.002	0.002	-0.000
New students from a Non-English speaking country (%)	-0.000	0.002	0.006	-0.007**
Public schools (yes/no)	-0.078**	-0.118***	0.048	0.148***

NOTES: This table reports estimates from multinomial logit models in which the polytomous dependent variable takes the values 0, 1, 2, or 3, corresponding respectively to the following categories of the number of students in MGC: 0, [1,19], [20,39], and [40,59]. The estimates are obtained separately for three intervals of Grade 3 enrollment, namely [20,24], [40,44], and [60,64]. The regressions are based on a panel of observations covering the 2017–2018 to 2022–2023 period. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

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

4.2 Results

4.2.1 Results from OLS

Table 4 reports the estimated coefficients for each of the academic achievement indicators. The first specification includes only the number of third-grade students in MGCs, whereas the second additionally incorporates school-level and socioeconomic covariates, as well as year fixed effects and school-district fixed effects. The latter account for the potential influence of district-specific education policies on average school performance.

The results clearly indicate a negative association between academic achievement indicators and the number of students in MGCs, in both the restricted and the full models. Moreover, for each indicator, the coefficient associated with the number of third-grade

students in MGCs varies only marginally across the two specifications. In the model without control variables, the estimated coefficients are -0.098 , -0.102 , and -0.131 for reading, writing, and mathematics achievement rates, respectively. In the model, including the explanatory variables, these coefficients are -0.110 , -0.153 , and -0.136 . All of these coefficients are statistically significant at the 1% level.

In addition, the estimated effects of the socioeconomic variables on the three academic achievement indicators exhibit the expected signs. With the exception of the percentage of newly enrolled students from non-English-speaking countries, all of these effects are statistically significant at the 1% level. Finally, public schools display, on average, lower levels of academic achievement than Catholic schools.

TABLE 4
OLS Regression Results

Academic Achievement Indicators :	Reading		Writing		Mathematics	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Explanatory Variables</i>						
Students receiving special educ.services (%)		-0.308*** (0.021)		-0.329*** (0.025)		-0.386*** (0.024)
Gifted students (%)		0.202*** (0.031)		0.213*** (0.039)		0.340*** (0.041)
School-Aged Children in Low-Income Household (%)		-0.303*** (0.015)		-0.284*** (0.018)		-0.443*** (0.017)
Students Whose Parents Have No Diploma		-0.361*** (0.023)		-0.336*** (0.026)		-0.353*** (0.025)
New students from a Non-English speaking country (%)		-0.060*** (0.021)		0.001 (0.024)		0.018 (0.023)
Public schools (yes/no)		-35.268*** (1.943)		-35.901*** (2.196)		-37.463*** (2.112)
Third-Grade Enrollment		0.051*** (0.006)		0.074*** (0.007)		0.073*** (0.007)
Number of Third-Grade Students in MGCs	-0.098*** (0.011)	-0.110*** (0.009)	-0.102*** (0.012)	-0.153*** (0.011)	-0.131*** (0.012)	-0.136*** (0.011)
Number of Schools						
N	14,469	14,430	14,465	14,426	14,702	14,663
R ²	0.005	0.311	0.004	0.284	0.007	0.325

This table displays the results of estimating equation (2.2) using ordinary least squares (OLS) on a panel dataset spanning the years 2017–2018 to 2022–2023. Two sets of estimates are provided for each academic achievement indicator: the first specification includes only the number of third-grade students in MGCs, while the second additionally incorporates school-level and socioeconomic variables, as well as year fixed effects and school-district fixed effects. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

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

The relatively similar estimates of the coefficient associated with multigrade classes in the restricted specifications (Columns 1, 3, and 5 of Table 4) and the full specifications (Columns 2, 4, and 6 of Table 4) for educational achievement raise the question of the magnitude of potential endogeneity bias affecting the estimated effect of this variable. Indeed, in the presence of omitted variables correlated with both the multigrade-class variable and the dependent variable, the inclusion of additional control variables would, in principle, be expected to alter the estimated coefficient on the MGC variable. The relative

stability of this coefficient across specifications suggests that such a bias may be limited, although it cannot be formally ruled out.

This hypothesis of limited endogeneity bias is partially supported by the estimates reported in Table 2, where only a small number of control variables are found to be significantly associated with the number of students in multigrade classes. However, the estimates from the multinomial logit model (Table 3) indicate that several of these variables are statistically significant, with effects that differ in sign depending on the number of students in multigrade classes defined according to the various school-enrollment thresholds.

To examine the robustness of the OLS estimates to potential omitted-variable bias associated with the MGC variable, we implemented the sensitivity analysis developed by Emily Oster (2019). This procedure assesses the extent to which the estimated causal effect may be driven by unobserved confounders. The approach assumes that selection on unobservable is proportional to selection on observable and exploits the joint variation in the estimated coefficient and the coefficient of determination (R^2) resulting from the inclusion of control variables to infer the potential magnitude of omitted-variable bias.

The procedure consists of computing, under alternative assumptions regarding the maximum attainable coefficient of determination ($R_{\max}$) and the proportional-selection parameter (δ), the identified set for the coefficient β associated with the MGC variable. The upper bound of this set corresponds to the coefficient estimated in the controlled specification ($\tilde{\beta}$), obtained under the assumption that $R_{\max}$ is equal to the observed coefficient of determination in that specification ($\tilde{R}^2$). This assumption implies that no additional unobservable factors increase the explanatory power of the model beyond that already captured by the observed control variables. The lower bound corresponds to the coefficient (β^*), adjusted for potential omitted-variable bias under alternative assumptions regarding ($R_{\max}$) and the proportional-selection parameter (δ). Our objective is ultimately to assess whether the identified set $[\tilde{\beta}, \beta^*(R_{\max}, \delta)]$ contains zero¹⁰.

The values considered for $R_{\max}$ are 0.8, 0.6, and the value recommended by Emily Oster (2019), namely $1.3 \times \tilde{R}^2$. The values of the proportional-selection parameter δ are set to 1, 1.5, 2, and 0.5. For instance, the combination $R_{\max} = 0.6$ et $\delta = 1.5$ assumes that a model including both observed and unobserved determinants of achievement rates could explain up to 60% of the observed variance in these outcomes. It further assumes that the selection on unobserved confounders is 50% stronger than the selection on the observed confounders included in the model.

The results of the sensitivity analysis are reported in Table 5 for reading achievement rates (Panel A), writing achievement rates (Panel B), and mathematics achievement rates (Panel C). They indicate that the estimated coefficients associated with MGC are generally robust to the assumptions imposed on both the proportional-selection parameter δ and the

¹⁰ The sensitivity analysis is implemented using the Stata command *psacalc* in Stata.

maximum coefficient of determination $R_{\max}$. Across all scenarios considered, the identified sets for the coefficient on multigrade classes remain strictly negative and never include zero, with the exception of the results for writing achievement when $R_{\max}$ is set to 0.6 or 0.8 and $\delta = 2$. In this specific case, the estimated effect would be driven to zero only if selection on unobserved confounders were twice as strong as selection on the observed controls included in the model. This assumption appears relatively demanding given the number and relevance of control variables already included in the analysis. Overall, the results suggest that omitted-variable bias of a reasonably plausible magnitude would not be sufficient to overturn the negative sign or the existence of an effect associated with MGCs.

Table 5
Sensitivity analysis to omitted variables
(Oster, 2019)

Panel A : Achievement rate in reading				
Treatment effect : β , (Std. error), [R2]				
Baseline effect : -0.056***(-0.011)[0.169]				
Controlled effect (all X's) : -0.110***(-0.010)[0.311]				
Bounds on β				
δ	0.8	$R_{\max}$ 0.6	$\tilde{R} \times 1.3$	
1	[-0.337,-0.110]	[-0.260,-0.110]	[-0.148,-0.110]	
1.5	[-0.502,-0.110]	[-0.355,-0.110]	[-0.168,-0.110]	
2	[-0.844,-0.110]	[-0.487,-0.110]	[-0.189,-0.110]	
0.5	[-0.213,-0.110]	[-0.180,-0.110]	[-0.128,-0.110]	
Panel B : Achievement rate in writing				
Treatment effect : β , (Std. error), [R2]				
Baseline effect : -0.091***(-0.013)[0.189]				
Controlled effect (all X's) : -0.153***(-0.012)[0.284]				
Bounds on β				
δ	0.8	$R_{\max}$ 0.6	$\tilde{R} \times 1.3$	
1	[-0.580,-0.153]	[-0.437,-0.153]	[-0.211,-0.153]	
1.5	[-1.026,-0.153]	[-0.658,-0.153]	[-0.243,-0.153]	
2	[-0.153,1.858]	[-0.153,1.936]	[-0.279,-0.153]	
0.5	[-0.339,-0.153]	[-0.282,-0.153]	[-0.181,-0.153]	
Panel C : Achievement rate in mathematics				
Effet de traitement β				
Baseline effect : -0.072***-0.013[0.166]				
Controlled effect (all X's) : -0.136***-0.012[0.325]				
Bounds on β				
δ	0.8	$R_{\max}$ 0.6	$\tilde{R} \times 1.3$	
1	[-0.353,-0.136]	[-0.280,-0.136]	[-0.177,-0.136]	
1.5	[-0.492,-0.136]	[-0.364,-0.136]	[-0.198,-0.136]	
2	[-0.688,-0.136]	[-0.466,-0.136]	[-0.221,-0.136]	
0.5	[-0.238,-0.136]	[-0.205,-0.136]	[-0.156,-0.136]	

NOTES: This table presents the sensitivity analysis to omitted variables proposed by Emily Oster (2019). The baseline effect corresponds to a specification including only year fixed effects and school board fixed effects. The controlled effect incorporates the full set of observable determinants of achievement rates used in the analysis. The identified sets for the coefficient associated with multigrade classes are obtained under alternative assumptions regarding the maximum attainable coefficient of determination ($R_{\max}$) and the proportional-selection parameter (δ). The lower bound of each interval corresponds to the bias-adjusted coefficient (β^*), while the upper bound corresponds to the coefficient estimated in the controlled specification ($\tilde{\beta}$).

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

4.2.2 Results from 2SLS

Table 6 presents the estimated effects of the number of Grade 3 students enrolled in multigrade classes (MGCs), using an instrumental variable approach. Columns (1) to (3) report estimates obtained under the assumption of a linear relationship between achievement rates and school enrollment, whereas columns (4) to (6) report estimates obtained under the assumption of a quadratic relationship. The inclusion of a quadratic term allows for potential nonlinearities in the relationship between school enrollment and achievement and, thereby, reduces the risk that this relationship may be confounded by the discontinuities associated with the maximum class-size threshold for Grade 3 or its multiples, which constitute the exogenous source of identification for the effect of MGCs.

As in the OLS estimates, the estimated effects of the potential confounding factors on academic achievement are consistent with expectations. Thus, the percentage of students receiving special education services, which serves as an indicator of the proportion of Grade 3 students experiencing learning difficulties, is associated with a lower average achievement rate among these students. Conversely, the percentage of students identified as gifted is associated with a higher achievement rate. Similarly, a higher proportion of students living in low-income households or whose parents have no formal diploma is associated with lower rates of Grade 3 students meeting the provincial standard in reading, writing, or mathematics. Finally, being a public rather than a Catholic school is, on average, associated with lower achievement rates among Grade 3 students.

The estimates reported in Table 6 indicate that an increase in the number of Grade 3 students who share a class with Grade 2 or Grade 4 students leads to a decrease in average achievement rates in reading, writing, and mathematics. Specifically, adding one Grade 3 student to a multigrade class (MGC) reduces the average reading achievement rate by 0.099 and 0.113 percentage points, respectively, for schools with 0–19 and 20–39 Grade 3 students enrolled in MGCs. The estimated effect of MGCs is not statistically significant for schools with 40–59 Grade 3 students enrolled in MGCs. Moreover, the estimated effects remain very similar when the relationship between school enrollment and achievement rates is specified as quadratic.

The estimated effects on writing achievement are larger, corresponding to a decrease of 0.137 and 0.167 percentage points, respectively, for the first two groups of Grade 3 students enrolled in MGCs (columns [1] and [2] of Table 3) under a linear specification of school enrollment. The estimated effects remain very similar when the relationship between school enrollment and achievement rates is specified as quadratic. Finally, the estimated effects of MGCs on average achievement rates in mathematics are comparable to those estimated for writing.

TABLE 6

IV regression results

Number of grade 3 students in multi-grade classes :	Linear effect - enrollment			Quadratic effect - enrollment		
	1 to 19	20 to 39	40 to 59	1 to 19	20 to 39	40 to 59
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A : Grade 3 Students Achieving the Provincial Standard in Reading (%)						
Students receiving special educ.services (%)	-0.296*** (0.029)	-0.313*** (0.036)	-0.528*** (0.117)	-0.293*** (0.030)	-0.313*** (0.036)	-0.530*** (0.117)
Gifted students (%)	0.221*** (0.048)	0.190*** (0.047)	0.331** (0.165)	0.220*** (0.048)	0.190*** (0.047)	0.329*** (0.165)
School-Aged Children in Low-Income Household (%)	-0.273*** (0.022)	-0.327*** (0.026)	-0.217** (0.085)	-0.274*** (0.022)	-0.327*** (0.026)	-0.218** (0.085)
Students Whose Parents Have No Diploma	-0.322*** (0.033)	-0.409*** (0.037)	-0.823*** (0.130)	-0.321*** (0.033)	-0.409*** (0.037)	-0.822*** (0.130)
New students to Canada from a Non-English speaking country (%)	-0.145*** (0.030)	0.042 (0.035)	0.115 (0.090)	-0.145*** (0.030)	0.042 (0.035)	0.114 (0.090)
Public schools (yes/no)	-35.765*** (2.457)	-29.743*** (5.869)	-56.615*** (11.724)	-35.672*** (2.452)	-29.761*** (5.866)	-56.643*** (11.722)
3rd year school enrollment	0.062*** (0.008)	0.041*** (0.010)	0.062** (0.031)	0.097*** (0.028)	0.027 (0.039)	0.004 (0.198)
3rd year school enrollment squared (/100)				-0.063** (0.030)	0.012 (0.042)	0.227 (0.155)
Grade 3 students in multi-grade classrooms (predicted)	-0.099** (0.043)	-0.113** (0.050)	-0.093 (0.133)	-0.097** (0.044)	-0.110** (0.050)	-0.085 (0.140)
Panel B : Grade 3 Students Achieving the Provincial Standard in Writing (%)						
Students receiving special educ.services (%)	-0.316*** (0.035)	-0.326*** (0.043)	-0.524*** (0.132)	-0.310*** (0.035)	-0.326*** (0.043)	-0.533*** (0.133)
Gifted students (%)	0.294*** (0.061)	0.173*** (0.055)	0.143 (0.191)	0.292*** (0.061)	0.173*** (0.055)	0.137 (0.190)
School-Aged Children in Low-Income Hous (%)	-0.256*** (0.025)	-0.321*** (0.031)	-0.015 (0.103)	-0.257*** (0.025)	-0.321*** (0.031)	-0.021 (0.103)
Students Whose Parents Have No Diploma	-0.282*** (0.037)	-0.380*** (0.044)	-1.030*** (0.154)	-0.280*** (0.037)	-0.380*** (0.044)	-1.022*** (0.154)
New students to Canada from a Non-English speaking country (%)	-0.083** (0.034)	0.128*** (0.041)	0.081 (0.104)	-0.083** (0.034)	0.128*** (0.041)	0.080 (0.104)
Public schools (yes/no)	-38.381*** (2.849)	-35.094*** (5.849)	-43.494*** (15.794)	-38.184*** (2.840)	-35.110*** (5.847)	-43.649*** (15.783)
3rd year school enrollment	0.101*** (0.010)	0.052*** (0.012)	0.047 (0.035)	0.161*** (0.033)	0.039 (0.049)	-0.266 (0.226)
3rd year school enrollment squared (/100)				-0.063** (0.030)	0.012 (0.042)	0.227 (0.155)
Grade 3 students in multi-grade classrooms (predicted)	-0.137*** (0.052)	-0.167*** (0.061)	-0.143 (0.154)	-0.133** (0.052)	-0.164*** (0.062)	-0.099 (0.160)
Panel C : Grade 3 Students Achieving the Provincial Standard in Mathematics (%)						
Students receiving special educ.services (%)	-0.391*** (0.034)	-0.391*** (0.041)	-0.422*** (0.134)	-0.385*** (0.034)	-0.388*** (0.041)	-0.427*** (0.134)
Gifted students (%)	0.381*** (0.065)	0.337*** (0.056)	0.238 (0.188)	0.379*** (0.065)	0.337*** (0.056)	0.234 (0.186)
School-Aged Children in Low-Income Hous (%)	-0.413*** (0.024)	-0.469*** (0.029)	-0.431*** (0.086)	-0.413*** (0.024)	-0.468*** (0.029)	-0.434*** (0.086)
Students Whose Parents Have No Diploma	-0.309*** (0.036)	-0.387*** (0.042)	-0.785*** (0.142)	-0.308*** (0.036)	-0.388*** (0.042)	-0.780*** (0.143)
New students to Canada from a Non-English speaking country (%)	-0.056 (0.034)	0.114*** (0.038)	0.213** (0.104)	-0.057* (0.034)	0.115*** (0.038)	0.213** (0.104)
Public schools (yes/no)	-38.673*** (2.864)	-33.082*** (6.868)	-40.373*** (11.906)	-38.473*** (2.852)	-33.021*** (6.905)	-40.458*** (11.901)
3rd year school enrollment	0.085*** (0.010)	0.070*** (0.012)	0.090*** (0.035)	0.143*** (0.033)	0.118** (0.048)	-0.081 (0.206)
3rd year school enrollment squared (/100)				-0.060** (0.030)	-0.045 (0.042)	0.124 (0.141)
Grade 3 students in multi-grade classrooms (predicted)	-0.133*** (0.051)	-0.159*** (0.057)	-0.121 (0.138)	-0.130** (0.051)	-0.171*** (0.059)	-0.097 (0.141)
Number of schools	6 414	3 935	439	6 414	3 935	439
Observations						

NOTES: This table reports the estimates of the equation (2.2) obtained using Two-Stage Least Squares (2SLS) methods. Two sets of estimates are presented: columns (1) to (3) report estimates obtained under the assumption of a linear relationship between achievement rates and school enrollment, whereas columns (4) to (6) report estimates obtained under the assumption of a quadratic relationship. The estimates are based on a panel of observations covering the period from 2017–2018 to 2022–2023. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

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

4.3 RDD findings

The results obtained using the RDD approach are presented in Table 7. The effects of MGCs were estimated for three groups of schools, defined according to their number of Grade 3 students: schools with 15–24, 35–44, and 55–64 Grade 3 students, respectively. These intervals correspond to the observation windows selected around the thresholds of 20, 40, and 60 Grade 3 students, respectively. For each of these groups, the effects were also estimated for three ranges of the number of students enrolled in MGCs: 1–19, 20–39, and 40–59 students. The results corresponding to these three ranges are reported in columns (1) to (3) of the table, respectively.

The estimated effects of a relatively small number of students enrolled in MGCs on reading achievement are generally positive, although only a limited number of these effects are statistically significant (Panel A of Table 7). More specifically, for schools with 20–24 Grade 3 students, having a relatively small number of students enrolled in MGCs—approximately 1 to fewer than 10 students—leads to an average increase of 1.953 percentage points in the reading achievement rate over the 2017–2018 to 2022–2023 period, and this effect is statistically significant.¹¹

The estimates for the groups of schools with 35–44 and 55–64 Grade 3 students are particularly informative, as they allow us to estimate the impact of MGCs in settings characterized by larger school enrollments and, consequently, by a greater number of students participating in MGCs in several schools. Thus, for the group of schools with 40–44 Grade 3 students, column (1) of Table 7 indicates that having a relatively small number of students enrolled in MGCs—fewer than approximately 10 students—leads to an increase of 2.081 percentage points in the reading achievement rate, compared with schools with approximately 20 students enrolled in MGCs.

With respect to the group of schools with 55–64 Grade 3 students and 20–39 Grade 3 students enrolled in MGCs (Section A, column (2) of Table 7), the results indicate that the reduction in the number of students enrolled in MGCs induced by crossing the 60-student Grade 3 enrollment threshold leads to a statistically significant increase of 2.429 percentage points in the average reading achievement rate. Thus, the achievement rate in schools with 60–64 Grade 3 students is, on average, 2.429 percentage points higher than that in schools with 55–59 Grade 3 students. It should be recalled that schools in the former group have fewer students participating in MGCs than those in the latter group. Finally, the estimates obtained for the other school groupings—namely, schools with 35–44 Grade 3 students and 20–39 students enrolled in MGCs, as well as schools with 55–64 Grade 3 students and either 1–19 or 40–59 students enrolled in MGCs—are also positive but are not statistically significant.

¹¹ 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.

Comparable effects are estimated for writing achievement rates (Section B of Table 7). Thus, in schools with 20–24 Grade 3 students and with the number of students enrolled in MGCs near the lower bound of the 1–19 range, a reduction in the number of students enrolled in MGCs leads to a statistically significant increase of 3.405 percentage points in the writing achievement rate. The corresponding differential and statistically significant effect reaches 4.847 percentage points in schools with 60–64 Grade 3 students and with slightly more than 20 students enrolled in MGCs (the [20,39] group). Again, positive effects are estimated for the other school groupings, although these effects are not statistically significant.

Finally, MGCs have a positive and statistically significant effect on mathematics achievement rates for several groups of schools with relatively smaller enrollments than those of schools whose Grade 3 enrollment lies just below the regulatory class-size threshold or its multiples. For schools with 1–19 students enrolled in MGCs (column (1) of Table 4), the effect of MGCs is estimated at 2.169, 1.968, and 2.872 percentage points for schools with 20–24, 40–44, and 60–64 Grade 3 students, respectively; these effects are statistically significant. The effect reaches 3.784 percentage points in schools with 60–64 Grade 3 students and with slightly more than 20 students enrolled in MGCs.

TABLE 7**Regression discontinuity results**

Number of grade 3 students in MGC	[1,19]	[20,39]	[40,59]
Panel A : Grade 3 Students Achieving the Provincial Standard in Reading (%)			
<i>Number of grade 3 students : [15,24]</i>			
20-student threshold indicator	1.953** (0.894)		
Number of observations	1,381		
<i>Number of grade 3 students : [35,44]</i>			
40-student threshold indicator	2.081** (0.882)	0.784 (0.912)	
Number of observations	962	871	
<i>Number of grade 3 students : [55,64]</i>			
60-student threshold indicator	1.304 (1.109)	2.429** (1.182)	0.976 (3.596)
Number of observations	442	417	109
Panel B : Grade 3 Students Achieving the Provincial Standard in writing (%)			
<i>Number of grade 3 students : [15,24]</i>			
20-student threshold indicator	3.405*** (1.111)		
<i>Number of grade 3 students : [35,44]</i>			
40-student threshold indicator	1.451 (1.087)	1.640 (1.122)	
<i>Number of grade 3 students : [55,64]</i>			
60-student threshold indicator	2.181 (1.465)	4.847*** (1.565)	0.172 (3.951)
Panel C : Grade 3 Students Achieving the Provincial Standard in mathematics (%)			
<i>Number of grade 3 students : [15,24]</i>			
20-student threshold indicator	2.169** (1.073)		
<i>Number of grade 3 students : [35,44]</i>			
40-student threshold indicator	1.968* (1.080)	1.354 (1.073)	
<i>Number of grade 3 students : [55,64]</i>			
60-student threshold indicator	2.872** (1.427)	3.784*** (1.319)	0.748 (2.913)

NOTES This table reports the estimates from the regression discontinuity analyses, excluding schools with no MGCs. The estimates are based on a panel of observations covering the period from 2017–2018 to 2022–2023. The observations were grouped according to three school-enrollment intervals, [15,24], [35,44], and [55,64], and three ranges of the number of students enrolled in MGCs, [1,19], [20,39], and [40,59], in order to exploit the discontinuities observed in Figure 2. The estimates were obtained using ordinary least squares regressions for different combinations of these intervals. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

SOURCE: Author's calculation 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 class-size literature. The second method relies on the regression discontinuity design.

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 to -0.2. 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 to two 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 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 20 students in MGCs. Similar patterns are observed for the other groupings, although only a few of the estimated effects are statistically significant.

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.

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