Stability of Socio-economic Gaps in Mathematics and Science Achievement Among Canadian Schools

Xin Ma

Using Canadian data from the Third International Mathematics and Science Study, I have examined the stability of within-school socio-economic gaps in mathematics and science achievement. Student characteristics had significant effects on student achievement. School characteristics were at most marginally related to school average achievement and had no effect on within-school socio-economic gaps. Within-school socio-economic gaps were highly correlated between mathematics and science, and this correlation was not affected by student and school characteristics. School average achievement was not correlated with within-school socio-economic gaps, and this relationship was not affected by student and school characteristics.

L'auteur analyse la stabilité des écarts socio-économiques à l'intérieur des écoles pour ce qui est des résultats en mathématiques et en sciences. Les résultats montrent, entre autres, que les caractéristiques des élèves affectent grandement leur rendement scolaire et qu'il existe une forte corrélation entre les écarts socio-économiques à l'intérieur de l'école et le rendement scolaire en mathématiques et en sciences, cette corrélation n'étant pas affectée par les caractéristiques des élèves et des écoles. De plus, il n'y a pas de corrélation entre le rendement moyen de l'établissement et les écarts socio-économiques à l'intérieur de l'établissement.

Gaps in educational attainment among individuals with differing socio-economic status (SES) have been characterized as the most enduring social phenomenon (White, 1982). Within a school, socio-economic discrepancy among students can cause either a small or a large difference in their academic achievement, referred to as the "socio-economic gap" in academic achievement. Although researchers have documented this within-school socio-economic gap in academic achievement (e.g., Gamoran, 1996), they are uncertain about whether the within-school socio-economic gap in academic achievement is stable across school subjects, and what student and school characteristics affect this stability. The purpose of this study was to address this lack of empirical knowledge by examining whether the socio-economic gap in academic achievement is consistent across two essential school subjects (mathematics and science), and by identifying student and school variables that influence this stability.

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SES has long been offered as a primary factor that contributes to differences in student academic achievement (Thomas, Sammons, Mortimore, & Smees, 1997). Widespread socio-economic gaps in academic achievement exist not only in industrial countries but also in developing countries (Ishida, Muller, & Ridge, 1995). This socio-economic gap often remains strong even after adjustment for student and family characteristics such as gender, age, number of parents, and number of siblings (see Caldas, 1993; Schultz, 1993).

In Canada, between 35% and 50% of the variation in academic achievement among elementary school students can be attributed to their SES (Lytton & Pyryt, 1998). Ma and Klinger (2000) reported that, among elementary school students in New Brunswick, SES is a significant predictor of their academic achievement across reading, writing, mathematics, and science. Hull (1990) has argued that the poor academic performance of Canadian Aboriginal students is essentially attributable to their disadvantaged SES. The latest Organisation for Economic Cooperation and Development (OECD) Programme for International Student Assessment (PISA) showed that SES is one of the four most important variables (associated with individual and family) that are responsible for the differential performance of Canadian students (aged 15) in reading, mathematics, and science (Human Resources Development Canada, Statistics Canada, & Council of Ministers of Education Canada, 2001).

Lee and Smith (1995) emphasized two different types of schools: bureaucratic and communal schools. Bureaucratically organized schools operate on a set of standardized rules and procedures and rely on affectively neutral (impersonal) social relationships to sustain school operation. Communally organized schools operate on a set of common missions and rely on informal, affective social interactions (interpersonal affective bonds) to facilitate school administration. A number of researchers have concluded that students' SES has a less stratifying effect on academic achievement in communally organized schools (these schools are socio-economically more equitable in academic achievement) (see Lee & Smith, 1996). Many researchers asserted that the affective bond between teachers and students is essential to motivate students to learn and engage them in learning (see Lee, Smith, & Croninger, 1997). Because of this advantage, many communally operated schools are able to benefit more from various educational reforms such as school restructuring that reduced the socio-economic gap in academic achievement across mathematics, science, reading, and history (Lee & Smith, 1995).

Studies such as Lee and Smith (1995) indicate that the within-school socio-economic gap in academic achievement can be different across school subjects, depending on the way a school is organized and operated, and many educators are becoming more aware of this issue. Instead of examining the within-school socio-economic gap in each school subject separately, the current study investigated the correlation of the within-school socio-economic gap in academic achievement across school subjects simultaneously. This type of research is important because it eventually brings to light answers to the question of whether schools are differentially successful in reducing the socio-economic gap in academic achievement across school subjects.

The issue of student performance in mathematics and science is particularly relevant in Canada today. The recent high standards in mathematics and science performance have led to the implementation of new programs of studies in many provinces (Council of Ministers of Education Canada, 1998). I focused on socio-economic equity in mathematics and science achievement. Data from the Third International Mathematics and Science Study (TIMSS) were considered appropriate, with nationally representative samples and with measures on academic achievement as well as information on student and school characteristics. Using the Canadian data from TIMSS, four research questions were examined:

1. What student and school characteristics affect mathematics and science achievement, and what student and school characteristics affect the within-school socio-economic gap in mathematics and science achievement?
2. What is the correlation between the within-school socio-economic gap in achievement in mathematics and that in science among schools? (Do schools that have a large socio-economic gap in mathematics also have a large socio-economic gap in science?)
3. What student and school characteristics contribute to the correlation among schools between the within-school, socio-economic gap in achievement for mathematics and for science?
4. What are the relationships between the school average mathematics and science achievement and the within-school socio-economic gap in mathematics and science achievement?

METHOD

Data

Data analyzed in this study came from the TIMSS. Population 1 targeted 9-year-old students who were in grades 3 or 4, and Population 2 targeted 13-year-old students who were in grades 7 or 8. Students completed mathematics and science tests and a student questionnaire, and their mathematics and science teachers as well as their principals also completed a teacher questionnaire and a school questionnaire. The Canadian samples were taken from Populations 1 and 2 in the TIMSS. There were 16,002 students from 395 schools in Population 1, and 16,581 students from 380 schools in Population 2.

Measures

I used variables descriptive of student and school characteristics (see Appendix A) derived from the student questionnaire. One set included measures of academic achievement in mathematics and science as dependent variables. These achievement measures were in several forms of scores in the TIMSS. I adopted national Rasch scores in mathematics and science that were adjusted for reliability, difficulty, and guessing.

The other set of variables described student background characteristics, including gender, SES, age, family size, family structure, parent immigration status, and grade level. These variables were selected to achieve an adequate control of student and family background characteristics. Note that SES was measured differently between Populations 1 and 2. In Population 1, SES described home learning environment, with the number of education-related items (e.g., computers, dictionaries, and magazines) available at home (a crude measure of economic and cultural capital). In Population 2, SES combined parents' education level with home learning environment, and this SES measure was more accurate than that obtained in Population 1. Because each population contained students from two grade levels who used the same mathematics and science tests, the issue of test validity exists. Statistical adjustment was needed to control for the differential performance between students from different grade levels. One dummy variable was created to denote the grade level of a student.

Two sets of variables at the school level were derived from the school questionnaire (see Appendix A), corresponding to the theoretical scheme of school effects that classifies school characteristics into school context and climate (see Willms, 1992). School context included (a) school size, (b) the percentage of students coming from disadvantaged socio-economic background (a measure of the school socio-economic composition), and (c) the percentage of students with a language other than that taught in school (a measure of the school immigrant composition). Students were considered socially disadvantaged if they were in government support programs (e.g., lunch, transportation, learning materials, and stationeries provided free or at reduced cost). Students with a language other than that used in school were loosely defined as students with language problems or difficulties. These variables capture what researchers often refer to as "student intake of a school," a major component of school context.

School climate included (a) staff co-operation, (b) teacher influence, and (c) disciplinary climate. These variables contain scales with items that closely reflect the theoretical scheme of school effects (Willms, 1992). Therefore, the validity of these scales was evident. For teacher influence, Cronbach's alpha was 0.88 in Population 1 and 0.86 in Population 2; for disciplinary climate, 0.95 in Population 1 and 0.89 in Population 2. Because the three items describing staff co-operation were all dichotomous, factor analysis was used to make sure that these items all measured the same latent factor in both populations. Finally, these school climate variables were scaled in such a way that a higher value indicated a more positive response.

For the purpose of analysis, non-dichotomous variables at both the student and school levels were standardized to have a mean of zero and a standard deviation of one. Student-level dichotomous variables were centred around their grand means. Influences of variables were calculated as effect sizes, and then transformed to a more familiar scale, with a mean of 500 and a standard deviation of 100. Such a scale is often used in standardized achievement tests such as the Scholastic Aptitude Test (SAT). Thus, an effect size for a particular variable of, say, 0.06 standard deviations would be interpreted as indicating a difference in achievement of six points (i.e., 500 versus 506), as a result of that variable.

Statistical Procedures

I took a multivariate, multilevel approach to statistical analysis. I developed a three-level hierarchical linear model (HLM) to examine the stability of the socio-economic gap in academic achievement across mathematics and science[1]. Briefly, the first level is a measurement model (within-student model) with two dichotomous variables denoting mathematics and science. The second level is a student model (between-student model), in which SES gaps in mathematics and science achievement are examined among students with adjustment for student characteristics. The third level is a school model (between-school model) in which within-school SES gaps in mathematics and science achievement are examined among schools with adjustment for school characteristics.

Three HLM models were tested. The first contained the two dichotomous indicators at the first level, SES at the second (student) level, and no variables at the third (school) level. The purpose of this model was to estimate variance and covariance in socio-economic gaps in and between mathematics and science achievement without any adjustment for student and school characteristics. The second model introduced student-level variables to the first model. This model produced estimates of variance and covariance in socio-economic gaps in and between mathematics and science achievement, adjusted for student characteristics. The third model was the "full" model with all variables at the student and school levels. This model produced estimates of variance and covariance in socio-economic gaps in and between mathematics and science achievement, adjusted for both student and school characteristics. Because each HLM model yielded variance and covariance in socio-economic gaps in and between mathematics and science achievement, correlation between socio-economic gaps in mathematics and science achievement could be calculated as a measure of the stability of the socio-economic gap in achievement across mathematics and science.

There were missing data in the school questionnaires in the current study (ranging from 7.1% to 18.5% in Population 1 and from 7.6% to 20.6% in Population 2). When applying HLM models, missing data are disallowed at the second and third levels. Deletion of missing data was not used because it eliminated one-third of the schools. I imputed missing data with the EM (expectation maximization) algorithm (Hill, 1997). This strategy kept all schools in the data analysis to maintain a fair generalization of the results to the populations.

TABLE 1

Descriptive Statistics of Outcome Measures, Student Characteristics, and School Characteristics

	Population 1		Population 2	
	Mean	SD	Mean	SD
Outcome measures				
Mathematics achievement	17.12	8.30	21.72	7.75
Science achievement	17.56	7.27	20.72	6.13
Student characteristics				
Female (vs. male)	0.50	0.50	0.50	0.50
Socio-economic status (SES)	5.40	2.07	0.00	1.00
Age	9.56	0.74	13.64	0.78
Family size	4.66	1.40	4.54	1.31
Non-parent (vs. both parents)	0.02	0.13	0.02	0.13
Single parent (vs. both parents)	0.17	0.38	0.17	0.37
Both parents immigrant (vs. both parents native)	0.18	0.39	0.18	0.39
One parent immigrant (vs. both parents native)	0.13	0.34	0.11	0.32
Grade 4 (vs. Grade 3), Grade 8 (vs. Grade 7)	0.52	0.50	0.50	0.50
School Characteristics				
School size	364.36	170.23	466.38	312.91
% of socially disadvantaged students	18.76	18.41	20.33	18.30
% of students without instructional language	16.33	23.23	17.17	23.26
Staff co-operation	0.77	0.26	0.78	0.25
Teacher influence	2.70	0.83	2.74	0.79
Disciplinary climate	3.26	0.87	3.03	0.72

RESULTS

Descriptive Information of Student and School Characteristics

Table 1 presents descriptive statistics. For outcome measures (mathematics and science achievement), the number of items answered correctly is reported (but national Rasch scores were used in statistical analysis). Means for dichotomous variables (female, non-parent, single parent, both parents immigrant, one parent immigrant, Grade 4, and Grade 8) indicated the proportion of students who were coded as 1. In Population 1, half of the students (50%) were female, one in 50 students (2%) lived without parents, nine in 50 students (18%) had both parents as immigrants, and slightly more than half the students (52%) were in grade 4.

Means of non-dichotomous student-level variables indicated that, on average, students had between 5 and 6 education-related items at home (measuring SES), were between 9 and 10 years in age, and had between 4 and 5 members in their immediate families. At the school level, average school size was about 364 students. On average, schools had about 19% of students from socially disadvantaged background, and about 16% of students did not use the language of instruction at home. Means of school climate variables were about 0.77 for staff co-operation in a scale of 0 to 1, about 2.70 for teacher influence in a scale of 1 to 4, and about 3.26 for disciplinary climate in a scale of 1 to 4. Note that a higher value for these variables indicated a more positive response.

Descriptive statistics for variables in Population 2 can be interpreted in a similar manner, except that SES was a standardized variable in Population 2 (combining parents' education level with the number of education-related items at home). Most student and school characteristics were comparable between Populations 1 and 2. Some discrepancies were observed, mainly at the school level (i.e., larger school size, somewhat higher percent of socially disadvantaged students, and somewhat worse disciplinary climate in Population 2 than in Population 1).

Effects of Student Characteristics

Table 2 presents standardized beta (regression) coefficients that indicate the effects of student and school characteristics on a student's individual achievement in mathematics and science, the school average achievement

TABLE 2

HLM Results Explaining Effects of Student and School Characteristics

	Population 1		Population 2	
	Math	Science	Math	Science
Effects on student individual achievement				
Female	–0.050***	–0.062***	–0.086***	–0.197***
Socio-economic status	0.116***	0.139***	0.232***	0.248***
Age	–0.056***	–0.035*	–0.227***	–0.158***
Family size	–0.044***	–0.057***	–0.029***	–0.060***
Non-parent	–0.217***	–0.278***	–0.300***	–0.245***
Single parent	–0.170***	–0.144***	–0.150***	–0.138***
Both parents immigrant	–0.134***	–0.173***	–0.018	–0.177***
One parent immigrant	–0.106***	–0.069**	–0.029	–0.010
Grade 4, grade 8	0.685***	0.530***	0.585***	0.423***
Effects on school average achievement				
School size	0.612*	0.631***	0.355***	0.351***
% socially disadvantaged	–0.005***	–0.002*	–0.003**	–0.002
% without language	–0.003**	–0.006***	–0.001	–0.004***
Staff co-operation	0.035	0.025	0.043*	–0.005
Teacher influence	–0.049**	–0.063**	–0.051**	–0.086***
Disciplinary climate	0.010	0.008	0.001	0.000
Effects on school socio-economic gap in achievement				
School size	0.000	–0.002	–0.008	–0.005
% socially disadvantaged	0.000	0.000	–0.000	0.000
% without language	–0.000	–0.000	0.001	0.000
Staff co-operation	–0.002	0.004	–0.004	–0.016*
Teacher influence	0.005	–0.001	–0.002	–0.010
Disciplinary climate	–0.014	–0.011	0.006	–0.004

Note. * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$. The effect of each variable indicates the expected change in achievement (in score) given one unit increase (in value) in the variable. For school size, the effect has been transformed from the natural logarithm scale to the original scale, and the effect has been adjusted to 100 students increase instead of one standard deviation increase.

in mathematics and science, and the within-school socio-economic gap in mathematics and science achievement. The first block of the table indicates the effects of student characteristics on the student achievement in mathematics and science. In terms of Population 1, gender differences in favor of males were observed in mathematics (effect = –0.050) and science (effect = –0.062). One can appreciate the magnitude of these effects (and other effects to come) with the familiar SAT scale discussed earlier (a mean of 500 and a standard deviation of 100). Results of gender differences indicate that if females scored 500, then males would score 505 in mathematics and 506 in science.

For a difference of one standard deviation in SES, if the student with lower SES scored 500, then the one with higher SES would score 512 in mathematics and 514 in science. For a difference of one year in age (within the same population), if the older student scored 500, then the younger one would score 506 in mathematics and 504 in science. For a difference of one person in family size, if the student from the larger family scored 500, then the one from the smaller family would score 504 in mathematics and 506 in science. If students having two parents scored 500, then those living with a non-parent would score 478 in mathematics and 472 in science; those living with one parent would score 483 in mathematics and 486 in science. If students with both parents born in Canada scored 500, then those with both immigrant parents would score 487 in mathematics and 483 in science; those with one immigrant parent would score 489 in mathematics and 493 in science.

Students in grade 4 outperformed students in grade 3. In the current study, however, the main purpose of including grade level was to statistically control for the differential performance of students from different grade levels. In sum, the non-parent variable was the most important, with a larger effect in science. Single parent, parent immigration status, and SES were the next important variables, with similar effects in mathematics and science. Gender, age, and family size had marginal effects.

In terms of Population 2, the non-parent variable had the most important effect, with a larger effect in mathematics. SES was the second important variable, with similar effects in mathematics and science. Age showed a significant effect in favour of younger students, particularly in mathematics. This age effect was outstanding even after control over students' grade levels. Single parent status was also important, with similar effects. Family size had marginal effects. Gender differences remained small in mathematics, but became sizable in science. Parent immigrant status was not significant in mathematics but students with both parents immigrants did have a sizable disadvantage in science.

Effects of School Characteristics

The second block in Table 2 shows how school context and climate affected the school average achievement in mathematics and science. In terms of Population 1, school size was significant in favour of large schools. For a difference of 100 students, if students in the smaller school scored 500, those in the larger school would score 561 in mathematics and 563 in science. The percentage of socially disadvantaged students and of students without instructional language had minor effects. For a difference of 10%, if the average achievement of the school with the higher percentage was 500, the average achievement of the school with the lower percentage of socially disadvantaged students would be 505 in mathematics and 502 in science, and the average achievement of the school with the lower percentage of students without instructional language would be 503 in mathematics and 506 in science.

As to school climate variables, only teacher influence had marginal, negative effects. Schools with stronger teacher influence had lower average achievement in mathematics and science than schools with weaker teacher influence. Overall, the effect of school size was large on the school average achievement in mathematics and science, while the percentage of socially disadvantaged students, the percentage of students without instructional language, and teacher influence had minor effects. Staff co-operation and disciplinary climate were unimportant to the school average achievement in mathematics and science.

In terms of Population 2, school size still affected the school average achievement in mathematics and science. The percentage of socially disadvantaged students had a minor effect only in mathematics, and the percentage of students without instructional language had a minor effect only in science. Effects of teacher influence remained marginal (and negative) in mathematics and science. Staff co-operation had a marginal effect only in mathematics.

The third block in Table 2 illustrates the effects of school characteristics on the within-school socio-economic gap. No school-level variables in the current study were able to explain the within-school socio-economic gap in either mathematics or science achievement across Populations 1 and 2. The only significant effect of staff co-operation was too trivial to warrant any practical concern. As a matter of fact, this isolated effect might well be the result of chance.

TABLE 3

Correlation Coefficients of Within-School Socio-economic Gaps in Achievement Between Mathematics and Science

	Unadjusted coefficient	Coefficient adjusted for student characteristics	Coefficient adjusted for student and school characteristics
Population 1	0.987	0.966	0.946
Population 2	0.949	0.951	0.961

Correlation of Within-School Socio-economic Gaps in Achievement

In Table 3, correlation coefficients based on each of the three models were calculated for each population. The first pair was unadjusted, involving only SES at the student level and no school-level variables. The second pair was adjusted for all student-level variables, but again involved no school-level variables. The third pair was based on the model involving all student-level and school-level variables. A large difference between an unadjusted and an adjusted coefficient indicates that the characteristics used for the adjustment affect the correlation of within-school socio-economic gaps.

In terms of Population 1, the unadjusted coefficient (0.987) indicated that within-school socio-economic gaps in achievement were highly correlated between mathematics and science. The three different types of correlation coefficients were also quite similar in magnitude. This result indicated that the correlation of within-school socio-economic gaps in achievement between mathematics and science was not much affected by either student characteristics or student and school characteristics. A very similar phenomenon was observed in Population 2.

School Average Achievement and Within-School Socio-economic Gap in Achievement

Table 4 shows that, in Population 1, the within-school socio-economic gap in mathematics achievement was hardly correlated with either school average mathematics achievement (the largest coefficient was 0.409) or school average science achievement (the largest coefficient was 0.493). Broadly speaking, schools with higher average mathematics and science

TABLE 4

Correlation Coefficients Between School Average Academic Achievement and School Socio-economic Gap in Academic Achievement

	School average in mathematics			School average in science		
	C1	C2	C3	C1	C2	C3
Population 1						
School socio-economic gap in mathematics	0.189	0.280	0.409	0.265	0.404	0.493
School socio-economic gap in science	0.121	0.115	0.166	0.292	0.364	0.427
Population 2						
School socio-economic gap in mathematics	0.029	–0.092	–0.021	0.017	–0.022	0.079
School socio-economic gap in science	–0.029	–0.106	–0.005	0.194	0.193	0.286

Notes. C1 = unadjusted coefficient. C2 = coefficient adjusted for student characteristics. C3 = coefficient adjusted for student and school characteristics (both school average academic achievement and school socio-economic gap in academic achievement are adjusted for school characteristics).

achievement showed somewhat larger socio-economic gaps in mathematics and science achievement. However, correlation coefficients such as the ones reported above indicate by no means perfect association. Sammons, Thomas, and Mortimore (1997) studied the correlation of average school performance among different school subjects, and they considered correlation coefficients around 0.60 as imperfect association without any meaningful implication for practice. The within-school socio-economic gap in science achievement was also hardly correlated with either school average mathematics achievement (the largest coefficient was 0.166) or school average science achievement (the largest coefficient was 0.427). Student and school characteristics did not have significant effects on these correlation coefficients.

In Population 2, the within-school socio-economic gap in mathematics achievement was not correlated with either school average mathematics achievement (the largest, absolute coefficient was 0.092) or school average science achievement (the largest coefficient was 0.079). Similarly, the within-school socio-economic gap in science achievement was not correlated with either school average mathematics achievement (the largest, absolute coefficient was 0.106) or school average science achievement (the largest coefficient was 0.286). Student and school characteristics did not affect these correlation coefficients.

DISCUSSION

Summary of Principal Findings

Student characteristics had significant effects on student achievement in mathematics and science. Family structure, SES, parent immigrant status (not important for mathematics achievement in Population 2), and age[2] (not important in Population 2) had important effects, whereas gender (the gender gap in science important only in Population 2) and family size had marginal effects. School characteristics were also related to the school average achievement in mathematics and science. The following school context variables were significant: school size (with important effects), the percentage of socially disadvantaged students (with marginal effects), and the percentage of students without instructional language (with marginal effects). The following school climate variables had marginal effects: teacher influence (with negative effects) and staff co-operation (on mathematics achievement in Population 2 only). No school context and climate variables used in the current study were responsible for within-school socio-economic gaps in mathematics and science achievement.[3]

Within-school socio-economic gaps in achievement were highly correlated between mathematics and science in both Populations 1 and 2, and this correlation was not much affected by student and school characteristics. The school average achievement in mathematics and science was hardly correlated with within-school socio-economic gaps in mathematics and science achievement in both Populations 1 and 2, and student and school characteristics did not affect their relationships. Several of these principal findings have rarely been observed in the literature and thus deserve some further discussions with policy implications.

Significant Role of Family Structure

Overall, family structure turned out to be the most important student-level variable for both mathematics and science achievement. The effect of family structure was quite comparable with (as a matter of fact stronger than in several cases) the effect of SES. Moreover, family structure showed significant (both statistically and practically) effects on both mathematics and science achievement even after controlling for SES. Such a finding was in great contrast to the secondary role of family structure to SES often shown in the literature. This significant role of family structure is not alone, however, in the literature. McLanahan (1997) attempted to determine which matters more to students, parental absence (family structure) or poverty (SES), and she concluded that "parent absence is more important than income" (p. 47) across a wide range of schooling outcomes. When families are disadvantaged in a functional sense, adequate social and educational support programs in school become critical to avoid adverse schooling outcomes for students from those families. Intervention may have to be implemented as early as the middle grades of elementary school.

Disadvantage of Students with Parents as Immigrants

Parent immigrant status had significant effects on mathematics and science achievement. A comparison between Populations 1 and 2 indicates that parent immigrant status mattered to student achievement in the early years of schooling. Students with both parents being immigrants showed especially sizable disadvantage in mathematics and science. Note that this disadvantage (with an effect of 0.134) was just as serious as the socio-economic disadvantage (with an effect of 0.116). This disadvantage of immigrant families fits into the broad literature on family resource allocation to children (Brooks-Gunn, Duncan, & Maritato, 1997). Recent statistics indicate that almost one third of immigrant families live in poverty in Canada, residing in low-income neighbourhoods, and one quarter of immigrant children aged 12 and younger enter Canada as refugees (Canadian Council on Social Development, 1998). Immigrant families often linger behind non-immigrant families in their ability to "expend resources on their children's health, education, and nurturance as investments that pay off later in the child's well-being as an adult" (Brooks-Gunn et al., 1997, p. 7). Tax benefits, training programs, and social networks have been identified as key measures to assist immigrant families disadvantaged in an economic sense (see Brooks-Gunn et al., 1997). These measures appear necessary given particularly that the disadvantage of students with both parents as immigrants remained (similar in size) in science achievement in Population 2.

Effects of School Size in Favour of Large Schools

Many current educational reforms are in favour of downsizing large schools (see Lee & Smith, 1995) because they tend to operate bureaucratically with impersonal relationships among administrators, teachers, and students (which discourage learning); while small schools tend to operate communally with affective bonds among staff and students (which promote learning). However, this study found a substantial advantage for large schools — they were consistently ahead of small schools in both mathematics and science achievement across both Populations 1 and 2. Furthermore, small schools did not show narrower within-school socio-economic gaps in mathematics and science achievement, as many education reformers expect. Of course, without information on operational practices of all schools, it is difficult to make policy implications out of the above findings.

Nevertheless, large schools usually have substantial funding advantages in Canada, and more school resources are related to better academic achievement (see Greenwald, Hedges, & Laine, 1996 for recent meta-analytic results). Confidence in the effect of large schools could be higher, if school location (urban, suburban, and rural) data were available. In general, urban and suburban schools tend to be much larger than rural schools. Therefore, the effects of school size in favour of large schools could reflect to some degree location effects between urban (suburban) and rural schools. Overall, the current study calls for more studies into the issue of school size before a policy of downsizing large schools is put into practice.

Minor Role of School Composition

This study showed surprisingly minor effects of school composition (percentage of students from disadvantaged SES and percentage of students without instructional language). Such minor differences in mathematics and science achievement between schools of different composition should certainly be credited to existing policies and programs that help schools in poor neighbourhoods and schools with a high concentration of immigrant students. Although these equities reflected in mathematics and science may not be true in reading and writing, which are typically school subjects where immigrant students tend not to fare well, these findings provide a basis for adjustment of policies and redistribution of resources that help consolidate progress made in mathematics and science and concentrate on potentially harder difficulties in other school subjects.

Negative Effects of Teacher Influence

Although the magnitude was marginal, the negative effects of teacher influence, which were so prevalent in this study (on both mathematics and science achievement in both Populations 1 and 2), need further investigation.[4] Many current education reforms advocate the empowerment of teachers. One way to empower teachers is to increase their influence on decision making in school operation. However, I found a consistently negative impact associated with teacher influence. Caution is needed not to predict prematurely the failure of teacher empowerment. Note that teacher influence as measured in TIMSS was mainly about curriculum-related decision making, such as determining curricular content and choosing textbooks. The negative effect of teacher influence may be an artifact because of the use of provincially unified curriculum in Canada, which tends to leave a somewhat limited room for teachers to influence curriculum decisions.

High Correlation of Within-School Socio-economic Gaps in Achievement

The major contribution of the current study to the literature is the finding that within-school socio-economic gaps in mathematics and science achievement were highly correlated. This indicates that schools with a large socio-economic gap in mathematics also had a large socio-economic gap in science. In other words, within-school socio-economic gaps in achievement were stable across mathematics and science. This stability existed even after adjustment for student and school characteristics. Particularly, school context and climate variables adopted from TIMSS for the current study were unable to unbalance the correlation of within-school socio-economic gaps in mathematics and science achievement.

This is not to say that changes in school context and climate have nothing to do with the correlation of within-school socio-economic gaps in mathematics and science achievement. In fact, the above finding suggests that changes in school context and climate either increase or decrease socio-economic gaps in both mathematics and science achievement simultaneously. The policy implication is that socio-economic inequalities in mathematics and science can be tackled together. This strategy actually brings teachers from mathematics and science together to work on common missions and effective approaches to reduce socio-economic inequalities in mathematics and science — an important step toward communal practices in school.

Lack of Relationship Between School Average Achievement and Within-School Socio-economic Gap in Achievement

The other major contribution of the current study to the literature is the finding that the school average in mathematics and science achievement was not correlated with within-school socio-economic gaps in mathematics and science achievement. Therefore, schools with a higher average achievement in mathematics and science did not necessarily have larger socio-economic gaps in mathematics and science achievement. This finding is an indication that the traditional effort to improve educational quality (e.g., school average achievement in mathematics and science) may not necessarily enlarge educational inequity (e.g., within-school socio-economic gaps in mathematics and science achievement). The concern that strategies to promote higher educational quality tend to make "the rich richer and the poor poorer" (larger educational inequity) may not be necessary. On the other hand, the effort to reduce educational inequity may not be necessarily at the cost of educational quality. The concern that high academic achievers (most of them from high SES families) tend to be disadvantaged in terms of their academic potential by efforts focusing on low academic achievers (most of them from low SES families) may not be necessary either.

POLICY REFLECTIONS

The high correlation of within-school socio-economic gaps between mathematics and science achievement suggests that, in general, schools (mathematics and science teachers) are equally successful in fighting socio-economic gaps in mathematics and science achievement. Currently, some Canadian provinces aim to promote academic achievement by means of school and teacher accountability. Such initiatives may not be fruitful from the perspective of socio-economic equity, as shown in this study. The lack of relationship between the school average achievement and the within-school socio-economic gap in achievement further indicates that school and teacher accountability is a complex policy issue. Some schools low in average academic achievement may have narrow socio-economic gaps in academic achievement. In other words, although these schools are unable to produce high achievement, they do very well in reducing social inequalities among their students. Such findings call for a careful review and a careful design of school and teacher accountability systems that should include multiple indicators of not only educational quality but also educational equity.

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NOTES

1. Details of this statistical model are available from the author
2. Students were born in different months of the same year, and the age effect is confounded with the grade level in which they were. This age effect was "purified" after control over the grade level.
3. The rather weak effects associated with school climate variables may be attributable to the way in which these variables are measured. Most items measuring disciplinary climate describe serious indiscipline scenarios not common in Canadian schools. Staff co-operation and teacher influence are both measured with three items, relatively fewer than those used in major large-scale national studies.
4. TIMSS data were collected in a period shortly before Ontario, the largest province in Canada, introduced more central control over school curricula, joining other Canadian provinces. The negative effects of teacher influence (or, loosely speaking, teacher empowerment) may be a local phenomenon (Ontario versus other Canadian provinces).

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APPENDIX A: DESCRIPTION OF OUTCOME MEASURES, STUDENT CHARACTERISTICS, AND SCHOOL CHARACTERISTICS

	Outcome Measures
Mathematics achievement	Mathematics achievement in Rasch scores (IRT scores)
Science achievement	Science achievement in Rasch scores (IRT scores)
	Student Characteristics
Gender	One vector (female = 1 vs. male = 0)
Socio-economic status (P1)	Student's report of the total number of items at home (i.e., home learning environment)
Socio-economic status (P2)	A combination of student's report of parents' education level and the total number of items at home
Age	Student's age in years
Family size	The number of people living with the student at home
Family structure	Two vectors (non parent vs. two parents, and single parent vs. two parents)
Parent immigration status	Two vectors (both immigrants vs. both natives, and one immigrant vs. both natives)
Grade level	One vector (Grade 4 = 1 vs. Grade 3 = 0 for Population 1; Grade 8 = 1 vs. Grade 7 = 0 for Population 2)
	School Characteristics
School size	Total enrollment of students transformed into natural logarithm because of its skewed distribution
Percent disadvantaged	Percent of students from disadvantaged socio-economic background
Percent language problem	Percent of students with language other than that taught in school
Staff co-operation	(a) Does your school have policy promoting cooperation and collaboration among teachers? (b) Are teachers encouraged to share and discuss instructional ideas and materials? (c) Do teachers in your school meet regularly to discuss instructional goals and issues? (1 = Yes; 2 = No)
Teacher influence	(a) How much influence do teachers collectively have in determining curriculum? (b) How much influence do teachers of a subject have in determining curriculum? (c) How much influence do individual teachers have in determining curriculum? (1 = none; 2 = a little; 3 = some; 4 = a lot)

Disciplinary climate	How often does school administration or staff have to deal with students (a) arriving late at school? (b) absenteeism? (c) skipping class periods? (d) violating the dress code? (e) classroom disturbance? (f) cheating? (g) profanity? (h) vandalism? (i) theft? (j) intimidation or verbal abuse of other students? (k) physical injury to other students? (l) intimation and verbal abuse of teachers or staff? (m) physical injury to teachers or staff? (1 = rarely; 2 = monthly; 3 = weekly; 4 = daily)

Note. Socio-economic status is measured differently between Population 1 (P1) and Population 2 (P2). Other variables have the same measurement in Populations 1 and 2.