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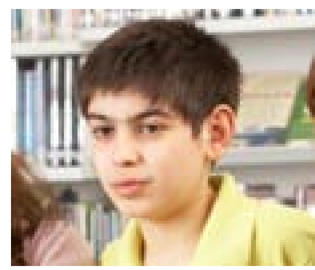
Performance in science on the Minnesota Comprehensive Assessments–Series II for students in grades 5 and 8



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Performance in science on the Minnesota Comprehensive Assessments–Series II for students in grades 5 and 8

April 2012

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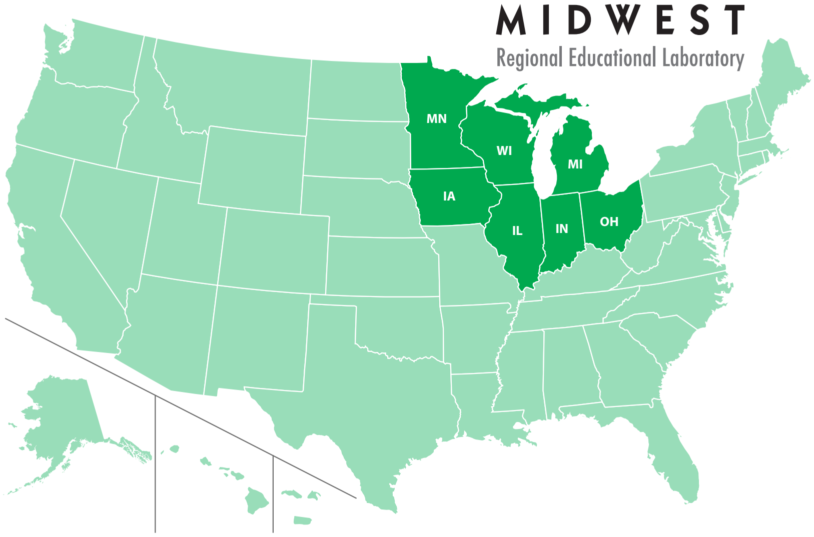

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April 2012

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REL 2012–No. 138

Performance in science on the Minnesota Comprehensive Assessments–Series II for students in grades 5 and 8

This study of statewide performance on the 2009/10 Minnesota state science assessment in grades 5 and 8 found that most of the variation in test scores was associated with demographic differences among students. Average performance differed by gender, eligibility for free or reduced-price lunch, special education status, and race/ethnicity.

Policymakers in Minnesota have made assessing and improving student science performance a priority (Minnesota High Tech Association 2010a,b). Minnesota has supported several statewide initiatives to promote science, technology, engineering, and math (STEM)—including a grant from the National Governors Association to increase science learning opportunities, align K–12 STEM education requirements with postsecondary workplace expectations, improve the quality and quantity of STEM teachers, benchmark standards, and identify best practices in STEM education (National Governors Association 2007). To gauge student progress toward the state's academic science standards, the Minnesota Department of Education introduced the Minnesota Comprehensive Assessments–Series II (MCA–II) science assessment in 2008.

Regional Educational Laboratory Midwest responded to a request by the Minnesota Department of Education to study elementary and middle school science achievement. The current study addresses three research questions:

- How does student achievement on the 2009/10 MCA–II science assessment in grades 5 and 8 differ by student demographic characteristics?
- How does schoolwide achievement on the 2009/10 MCA–II science assessment in grades 5 and 8 relate to school characteristics?
- To what extent do school characteristics explain differences in student achievement on the 2009/10 MCA–II science assessment in grades 5 and 8, after accounting for the influence of student characteristics?

This study used data for 51,510 grade 5 students in 786 schools and 52,421 grade 8 students in 469 schools. Five student demographic characteristics were considered: gender, eligibility for free or reduced-price lunch, special education status, race/ethnicity, and prior-year academic achievement. The school characteristics examined were based on student composition and teacher composition. The school characteristics based on student characteristics were the percentages of female students, students eligible

for free or reduced-price lunch, students identified as limited English proficient, students identified for special education services, and White students. The school characteristics based on teacher characteristics were the average years of teacher experience, the percentage of full-time equivalent credits[1] taught by teachers with a master's or doctoral degree, and the average student–teacher ratio.

Students' levels of science achievement depended on their demographic characteristics for both the grade 5 and grade 8 assessment:

- Students who were not identified for special education services scored higher than students who were.
- Students who were not eligible for free or reduced-price lunch scored higher than students who were.
- White students scored higher than students of other racial/ethnic groups.
- Male students scored higher than female students.

Eight of the nine school characteristics examined were related to schoolwide science achievement:

- Science achievement tended to be lower in schools with higher percentages of students eligible for free or reduced-price lunch, limited English proficient students, students identified for special education services, and non-White students.
- Science achievement tended to be higher in schools that had more experienced teachers, higher percentages of teachers with an advanced degree, larger student–teacher ratios, and higher levels of prior-year academic achievement.[2]
- Science achievement tended to be higher in schools with a higher proportion of female students in grade 8, but this relationship was not observed in grade 5.

About 80 percent of the variation in students' scores (79 percent in grade 5 and 84 percent in grade 8) was due to differences among students within schools; differences between schools accounted for the remaining variation. However, after accounting for student-level characteristics, the school characteristics examined explained less than 3 percent of the variation between schools (2.1 percent in grade 5 and 2.7 percent in grade 8). For both grades, after accounting for student characteristics, science achievement tended to be higher in schools with a smaller percentage of students eligible for free or reduced-price lunch and a larger percentage of White students.

Specifically, the following results were evident for both grades:

- A 1 percentage point increase in the percentage of White students was associated with an estimated increase in science assessment scores of 3.24 percentage points in grade 5 and 2.31 percentage points in grade 8.
- A 1 percentage point increase in the percentage of students eligible for free or reduced-price lunch was associated with an estimated decrease in science assessment scores of 2.33 percentage points in

grade 5 and 2.65 percentage points in grade 8.

None of the school characteristics based on teacher composition examined in this study were related to student science achievement after other student and school characteristics were accounted for.

This report provides Minnesota policymakers with insights into factors related to science achievement, as measured by the MCA–II. The analyses examine patterns of achievement but do not explain why the patterns occur. The findings identify demographic subgroups in Minnesota (such as non-White students and students eligible for free or reduced-price lunch) that could benefit from more intensive support in science. Findings are consistent with research by Stewart (2008) and Konstantopoulos (2006).

Differences in science achievement between limited English proficient students and those who are not limited English proficient could not be examined because of high levels of missing test data for limited English proficient students. Further, the study could examine only a limited set of school characteristics based primarily on student and teacher composition. The state might consider examining school characteristics related directly to science education, such as course and program offerings, science teacher performance, science teacher preparation and experience, and resources to support science instruction.

Notes

1. Full-time equivalent credits represent the amount of time per week a teacher is reported in a teaching assignment.

2. The student–teacher ratio is the average number of students per teacher in each school. In this study, student achievement tended to increase with the number of students per teacher. However, this could have been due to schools with more struggling students decreasing their class sizes to improve student achievement.

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This study of statewide performance on the 2009/10 Minnesota state science assessment in grades 5 and 8 found that most of the variation in test scores was associated with demographic differences among students. Average performance differed by gender, eligibility for free or reduced-price lunch, special education status, and race/ethnicity.

WHY THIS STUDY?

Concerned about future U.S. economic competitiveness and prosperity, policymakers nationwide and in Minnesota have renewed their interest in science, technology, engineering, and math (STEM; National Academy of Science 2005; Obama 2010; U.S. Department of Education 2006; Minnesota High Tech Association 2010a,b). To promote STEM fields, Minnesota has supported several statewide initiatives, including a web portal to link business resources with the needs of STEM educators (www.getstem-mn.com) and a website where parents and students can learn about the link between STEM fields and careers (www.mn-stem.com). In 2007, Minnesota received a grant from the National Governors Association to fund programs to increase science learning opportunities, align K–12 STEM education requirements with postsecondary workplace expectations, increase the quality and quantity of STEM teachers, benchmark standards, and identify best practices in STEM education (National Governors Association 2007).

In 2008, the Minnesota Department of Education introduced the Minnesota Comprehensive Assessments–Series II (MCA–II) science assessments to gauge student progress toward the state's academic science standards (see box 1 for a description of the MCA–II and appendix A on science standards). The assessment is administered every spring in grades 5 and 8, as well as once during grades 9–12 after a student completes a life science course. To help policymakers target resources to improve science achievement overall and to reduce achievement gaps, the Minnesota Department of Education asked Regional Educational Laboratory Midwest to examine MCA–II science assessment scores in grades 5 and 8 and to determine how the scores vary by student and school characteristics (see box 2 for definition of key terms).

BOX 1

Minnesota Comprehensive Assessment–Series II

Since 2008, the Minnesota Department of Education has administered the Minnesota Comprehensive Assessment–Series II (MCA–II) science assessment every spring in grades 5 and 8 and once in high school after a student completes a life science course. The assessment is aligned to the Minnesota K–12 Academic Standards in Science, which details students' expected knowledge in general science, physical science, earth and space science, and life science (see appendix A). Depending on the grade, each of these strands accounts for 22–32 percent of the assessment, with content specific to each grade (see Minnesota Department of Education 2009a for details of the assessment). The assessment is based on Webb's four depth of knowledge levels (Webb 1999):

- Recall of a fact, definition, term, or process.
- Skill/concept: mental processing beyond recall such as how to approach a problem.
- Strategic thinking: reasoning, planning, or use of evidence.
- Extended thinking: complex reasoning, planning, and thinking.

MCA–II is web-based, allowing for simulations of classroom experiments and manipulations of real-world visual representations (Minnesota Department of Education 2007).

MCA–II assessments have demonstrated strong validity and reliability. Content validity is shown by the use of experts to write the items based on standards, and scoring validity by agreement among raters on scoring of extended-response items, good item fit using item response theory analyses, and principal component analyses showing individual factors for each standard. Alpha reliability coefficients are 0.82 for the grade 5 test and 0.86 for the grade 8 test.[1]

The grade 5 assessment has a maximum score of 41 raw points derived from items related to 9–11 scenarios.[2] The items consist of 34 multiple-choice or figure-based items (1 point each), two short-response or figural[3] items (2 points each), and one extended-response item (3 points). The grade 8 assessment is similarly structured: 37 multiple-choice and figural-response items, four 2-point short-response or figural-response items, and one 3-point extended-response item based on 7–9 scenarios (48 raw points; Minnesota Department of Education 2008).

The Minnesota Department of Education converts the raw scores (points earned for answering items correctly) to scale scores using an item response theory model, which provides a consistent metric for forms of the assessment that vary in difficulty. The MCA–II scores for a given grade and subject are scaled from X01 to X99, where *X* is the grade being examined. In the current study, grade 5 students have an average score of 548.89 points (with a standard deviation of 13.52 points), and grade 8 students have an average score of 848.73 points (standard deviation of 10.38 points). The construction of the assessment does not allow grade 5 scores to be compared directly with grade 8 scores.

Notes

1. Coefficients of 0.80 are generally seen as the threshold of acceptable reliability (Nunnally 1978).
2. A sample scenario: "A student is growing a garden. In her garden, she is growing many types of fruits and vegetables, including bell peppers. Which of the following factors affecting the growth of pepper plants is biotic?"
3. For example, a figural item could require a student to construct or manipulate a graph.

Research questions

The current study addresses three research questions:

- How does student achievement on the 2009/10 MCA–II science assessment in grades 5 and 8 differ by student demographic characteristics?
- How does schoolwide achievement on the 2009/10 MCA–II science assessment in grades 5 and 8 relate to school characteristics?
- To what extent do school characteristics explain differences in student achievement on the 2009/10 MCA–II science assessment in grades 5 and 8, after accounting for the influence of student characteristics?

BOX 2

Key terms

Between-school variance. The proportion of variation in student test scores explained by school characteristics (such as percentage of students eligible for free or reduced-price lunch or student–teacher ratio) and schoolwide policies and practices.

Eligibility for free or reduced-price lunch. A commonly used indicator of low-income status. Students are eligible for free lunch if their household income is at or below 130 percent of the poverty level and for reduced-price lunch if the household income is 130–185 percent of the poverty level (U.S. Department of Agriculture 2010).

Full-time equivalent credits. The proportion of time per week an individual teacher is reported in a teaching assignment. This variable is used instead of the number of teachers, which can be misleading because some teachers work part-time and some serve in multiple or nonacademic roles (Minnesota Department of Education 2006). For more information, see Lewit and Baker (1997).

Limited English proficient students. Students for whom English is not their first language and who cannot perform typical class work in English (McCandless, Rossi, and Daugherty 1996).

Minnesota Comprehensive Assessment–Series II (MCA–II) scale scores. Raw scores converted to a common scale. Grade 5 scale scores range from 501 to 599 and grade 8 scale scores range from 801 to 899. For more information on the MCA–II science test, see box 1.

Multilevel modeling. A regression model used to analyze nested data (such as students within schools). It accounts for similarities among individuals (such as students) who belong to the same clusters (such as schools) by including a cluster-specific term (random effect) that is shared by all individuals in the cluster. This approach makes it possible to examine variance in science achievement attributable to differences within schools and between schools. It also estimates the relationship between student achievement and student- and school-level characteristics and accounts for the uncertainty in these estimates (that is, correctly calculates the standard errors of the estimates).

National Assessment of Educational Progress. Also known as the nation's report card, an ongoing assessment of the largest representative sample of students from U.S. schools in 12 subjects (including math, reading, and science). Results are reported nationally and by district and state for the entire sample and by demographic characteristic (National Center for Education Statistics 2011a).

Pearson correlation coefficient. A measure of the linear association between two variables, ranging from –1 (perfect negative relationship, meaning that as one variable increases, the other decreases), to 1 (perfect positive relationship, meaning that as one variable increases, the other increases). The coefficient equals 0 if the two variables are linearly unrelated.

Prior-year academic achievement. For students, a composite of a student's MCA–II math and reading test scores from the previous grade. For schools, the school average of composite math and reading student test scores.

School-level characteristics. Characteristics of schools such as the percentage of female students or average years of teacher experience in a given school. The same school-level characteristics were examined for grades 5 and 8. (See table B2 in appendix B for the characteristics examined in this study.)

Special education students. Students identified as needing special education services and who may or may not be receiving them.

Standard deviation. A measure of the amount of variation or spread in a distribution around the average. The greater the variance, the greater the standard deviation.

Standardized average difference. The difference between two group averages and the pooled standard deviation. The current study used Cohen's *d* to calculate the standardized average difference (or effect size), by taking the difference between two average scores (such as male and female student scores) divided by the pooled standard deviation to show the extent of the variation, or "spread," among scores of the two groups. Comparing the average differences

BOX 2 (CONTINUED)

Key terms

with the amount of variation in the two groups indicates whether the differences are meaningful. Higher Cohen's *d* values reflect larger average differences and less variation among the scores in the two groups. Cohen categorized standardized average differences of roughly 0.20 as small, differences of roughly 0.50 as medium, and differences of roughly 0.80 as large. Lipsey's (1989) review of education interventions generally confirms this categorization (small = 0.15, medium = 0.45, and large = 0.90).

Student-level characteristics. Characteristics of students, such as race/ethnicity or gender. The same student characteristics were examined for grade 5 and grade 8. (See table B2 in appendix B for the characteristics examined in this study.)

Variance explained. The proportion of variance (within or between schools) in student scores explained by the characteristics included in a multilevel model, which indicates the degree of influence that one characteristic (such as the percentage of female students in a school) or a group of characteristics (such as a school's student composition characteristics) has in explaining differences in student scores. The proportion of variance explained can range from 0 percent to 100 percent, with higher percentages indicating a stronger relationship between one characteristic (or a group of characteristics) and student scores.

Within-school variance. The amount of variation in student scores among students in the same school.

This study used data for 51,510 grade 5 students in 786 schools and 52,421 grade 8 students in 469 schools. Five student demographic characteristics were considered: gender, eligibility for free or reduced-price lunch, special education status, race/ethnicity, and prior-year academic achievement. The school characteristics examined were based on student composition and teacher composition. The school characteristics based on student characteristics were the percentages of female students, students eligible for free or reduced-price lunch, students identified as limited English proficient, students identified for special education services, and White students. The school characteristics based on teacher characteristics were the average years of teacher experience, the percentage of full-time equivalent credits[1] taught by teachers with a master's or doctoral degree, and the average student–teacher ratio.

Prior research on science achievement—Minnesota and nationally

Although little research specifically addresses science achievement in Minnesota, results from the 2009 National Assessment of Educational Progress (NAEP) in science show that 43 percent of grade 4 students in Minnesota scored proficient or higher on the 2009 NAEP in science compared with 32 percent nationwide, and 40 percent of grade 8 students scored proficient or higher compared with 29 percent nationwide.

However, some subgroups in Minnesota performed no better on the NAEP than their counterparts nationally. In particular, there were no statistically significant differences between Minnesota and national results in the percentages of students scoring proficient or higher for Black students, Hispanic students, and special education students in both grades 4 and 8 and for students eligible for free or reduced-price lunch in grade 4 (National Assessment of Educational Progress 2009).

Both nationally and in Minnesota, there are gaps in science achievement on the NAEP across student subgroups (U.S. Department of Education 2009a,b). NAEP science scores in grades 4 and 8 were higher for male students than for female students, for White students than for Black and Hispanic students, for students not eligible for free or reduced-price lunch than for eligible students, and for students identified for special education services than for students not identified.

NAEP results have indicated the importance of student-level characteristics in describing differences in science achievement, but the MCA–II science assessment is a new test that includes different items and gauges students' knowledge against different standards. Therefore, students may perform differently on the MCA–II than on the NAEP.

In 2009/10, fewer than half of Minnesota grade 5 students (46.0 percent) and grade 8 students (47.9 percent) achieved proficiency on the MCA–II science assessment, a rate lower than for math or reading (Minnesota Department of Education 2011). The Minnesota Department of Education website has an interactive tool that allows users to see gaps in MCA–II science scores and proficiency levels across student demographic characteristics. However, the tool does not indicate the magnitude of the differences across subgroups, nor does it examine the relationship between school-level characteristics and student science achievement, which are the focus of the current study.

Prior research on characteristics related to science achievement

Using 1992 National Education Longitudinal Study data, Konstantopoulos (2006) found that roughly 80 percent of student achievement in science is explained by differences in the characteristics of students within schools, and the other 20 percent by differences between schools. Other studies using different data also found that more of the variation in student achievement is explained by characteristics of students within schools than by differences between schools (Battistich et al. 1995; Lee and Bryk 1989).

Several studies have examined which school characteristics are related to student achievement. Some researchers have found that schools with disadvantaged student populations (those with high percentages of racial/ethnic minority students and students from low-income households) tend to have lower average student science and math achievement (Arnold and Kaufman 1992; Hogrebe, Kyei-Blankson, and Zou 2008; Konstantopolous 2006). By contrast, Stewart (2008) found that once student characteristics—household income, race/ethnicity, student effort, and positive peer relationships—are taken into account, a school's size, location, percentage of racial/ethnic minority students, and percentage of students from low-income households do not significantly relate to student achievement, measured by a composite of math, science, English, and history grades (see also Hanushek 1997).

The current study will provide information for Minnesota on the relationship between key student and school characteristics and science performance

Research examining teacher characteristics has found that degree attainment (Hogrebe et al. 2008) and teaching experience (Greenwald, Hedges, and Laine 1996) relate positively with measures of student achievement, while student–teacher ratios relate negatively (Finn and Achilles 1990; Konstantopolous 2006; Krueger and Whitmore 2001; McGiverin, Gilman, and Tillitski 1989; Nyhan and Alkadry 1999). The evidence, however, is inconsistent; other studies find that smaller class sizes are associated with lower academic performance.[2]

Overall, the research on the influence of school characteristics on student achievement, which has not been specific to Minnesota, is inconclusive. The current study will provide state-specific information for Minnesota on the relationship between key student and school characteristics and science performance. (Box 3 summarizes the study data and methods; details are in appendixes B and D–F.)

BOX 3

Data, samples, and methods

Data. The Minnesota Department of Education provided data on student- and school-level scale scores on the Minnesota Comprehensive Assessment–Series II (MCA–II) science assessment, student demographic characteristics, and teacher characteristics for public, charter, and magnet schools for 2009/10.[1] Duplicate student records or records missing one of the key analytic variables were deleted (13.2 percent of grade 5 students and 12.0 percent of grade 8 students; see appendix B for details). Missing data were related primarily to prior-year academic achievement, especially prior-year MCA–II math scores.[2]

The analytic samples retained more than 70 percent of students in each subgroup (see tables C1 and C3 in appendix C), except for limited English proficient students.[3] The analytic samples retained 40.6 percent of limited English proficient students in grade 5 and 45.0 percent in grade 8. Data tended to be missing for prior-year math scores, affecting 56.8 percent of grade 5 students and 49.3 percent of grade 8 students. For both grades, there were statistically significant differences between the limited English proficient students who had complete data on the current year's science scores and the prior year's reading and math scores and those with missing data. In addition, there were statistically significant differences between students who had missing data on race/ethnicity and identification as a special education student for grade 5 and on race/ethnicity for grade 8 and students who had complete data. These differences could make findings based on student-level data for limited English proficient students misleading, so they are not discussed in this report.[4]

Student analytic samples. The analyses included 51,510 students in grade 5 and 52,421 students in grade 8 in 2009/10. For both grades, approximately half the students were female, less than 35 percent were eligible for free or reduced-price lunch, less than 14 percent were identified for special education services, and more than 78 percent were White (table 1).

School analytic samples. The analyses included 786 schools for grade 5 and 469 schools for grade 8. On average, in schools enrolling grade 5 or grade 8 students, approximately half the students were female, less than 44 percent were eligible for free or reduced-price lunch, less than 11 percent were limited English proficient, less than 16 percent were identified for special education services, and more than 71 percent were White (table 2). Teachers in these schools had an average of approximately 14 years of teaching experience, less than half the credits were taught by teachers with an advanced degree (master's or doctoral) and there were an average of 16 students per teacher.

Methods. For the first research question, student science achievement in 2009/10 was compared across student characteristics. *T*-tests, adjusted for student clustering within schools, were used to determine whether differences in average science achievement by student characteristics were statistically significant. Since the analytic data set has more than 50,000 observations, even small differences could be statistically significant, so standardized average differences were calculated, using Cohen's *d* (Cohen 1988).

For the second research question, Pearson correlations were calculated between average schoolwide science achievement and school-level characteristics based on student composition[5] and teacher characteristics.

TABLE 1

Distribution of students in the analytic samples by student characteristic

Student characteristic	Grade 5 students		Grade 8 students	
	Number	Percent	Number	Percent
All students	51,510	100.00	52,421	100.00
Gender				
Male	26,223	50.9	26,548	50.6
Female	25,287	49.1	25,873	49.4
Free or reduced-price lunch				
Eligible	17,811	34.6	16,313	31.1
Not eligible	33,699	65.4	36,108	68.9
Special education status				
Identified	6,855	13.3	5,735	10.9
Not identified	44,655	86.7	46,686	89.1
Race/ethnicity				
White	40,506	78.6	41,964	80.1
Non-White[a]	11,004	21.4	10,457	20.0

Note: Percentages might not sum to 100 because of rounding.

a. For racial/ethnic minority breakdown, see tables C1 and C3 in appendix C.

Source: Authors' analysis based on data from the Minnesota Department of Education.

(CONTINUED)

BOX 3 (CONTINUED)

Data, samples, and methods

For the final research question, the study analyzed how much of the variation in individual student science achievement can be explained by differences among students in the same school (within-school variance) and how much by differences between the characteristics of schools (between-school variance). Also analyzed was how school-level characteristics relate to student achievement after accounting for the relationship between student characteristics and student achievement. Five multilevel regression models were estimated. First, a model without student or school characteristics was estimated to examine the extent to which differences in science scores can be attributed to differences within or across schools (model 1). Then, characteristics were entered successively: student-level demographic data (model 2), student-level prior achievement (model 3), school-level student composition (model 4), and school-level teacher characteristics (model 5).

Characteristics were entered in groups to explore how much of the remaining differences in science achievement were explained by different types of student- and school-level characteristics. In addition, regression coefficients were estimated to discern which school characteristics are significantly associated with individual science performance (see appendix D and table E2 in appendix E). Regression coefficients represent the relationship between school characteristics and student science scores, after taking into account the proportion of the relationship explained by other characteristics.

TABLE 2

Descriptive characteristics of schools included in the analytic samples

School characteristic	Grade 5	Grade 8
Percentage of female students	48.6 (3.99)	48.4 (4.88)
Percentage of students eligible for free or reduced-price lunch	43.7 (23.52)	40.0 (21.26)
Percentage of limited English proficient students	10.2 (16.29)	5.7 (13.19)
Percentage of students identified for special education services	14.3 (5.71)	15.2 (10.95)
Percentage of White students	71.6 (28.31)	78.0 (26.20)
Teachers' years of teaching experience	14.2 (4.00)	13.5 (3.66)
Percentage of full-time equivalent credits taught by teachers with an advanced degree[a]	49.7 (23.05)	43.1 (21.56)
Student–teacher ratio	15.7 (4.34)	15.7 (5.35)
Prior-year academic achievement (MCA–II standardized math and reading composite score)	–0.1 (0.46)	–0.2 (0.45)

Note: Percentages might not sum to 100 because of rounding. Numbers in parentheses are standard deviations. School characteristics were based on all students enrolled in each school in 2009/10 (not just grade 5 and grade 8 students), except for school average prior-year academic achievement, which is the average of the standardized grade 4 or grade 7 MCA–II math and reading composite score only for students in the grade 5 and grade 8 analytic samples. Negative values for prior-year academic achievement indicate that the average of schools based on the analytic sample was lower than the average of schools based on all students enrolled.

a. Calculated for each school by dividing the numbers of school-level full-time equivalent credits taught by teachers with a master's or doctoral degree by the sum of the numbers of school-level full-time equivalent credits taught by all teachers and then averaging across schools.

Source: Authors' analysis based on data from the Minnesota Department of Education.

Notes

1. The results for private school students and students who take alternative assessments typically are not reported by the Minnesota Department of Education and are not included in this study.
2. Less than 9 percent of students in each grade were missing prior-year academic achievement data, less than 4 percent were missing school characteristics, and less than 3 percent were missing demographic data or MCA–II science scores.
3. For grade 5, the subgroups with the largest percentages of students excluded from all analyses were limited English proficient (40.6 percent of data retained), Asian/Pacific Islander (70.8 percent retained), identified as special education (76.5 percent retained), and Black (78.5 percent retained) students (see table C1 in appendix C). For grade 8, the largest percentages of students excluded from all analyses were limited English proficient (45.0 percent of data retained), Hispanic (70.6 percent retained), special education identified (75.3 percent retained), and Black (77.8 percent retained) students (see table C3 in appendix C).
4. Data on school-level percentages of limited English proficient students were not affected by the missing data (for more detail, see tables F3–F6 in appendix F).
5. To reflect the global environment of the school, school composition characteristics were based on all students in a school, not just those in grades 5 and 8. There is less than a 10 percentage point difference in the school composition characteristics when calculated for all students (as in the current analysis) or when calculated for just grade 5 or grade 8 students. See table F2 in appendix F for a comparison across all school composition characteristics for both grade 5 and grade 8 students.

STUDY FINDINGS

This section presents the findings for each research question.

Differences in science achievement by student demographic characteristics

There were statistically significant differences in science achievement for each grade in all four subgroup comparisons (figures 1 and 2 and table 1; table F1 in appendix F shows the *t*-statistics and *p*-values associated with the subgroup differences).

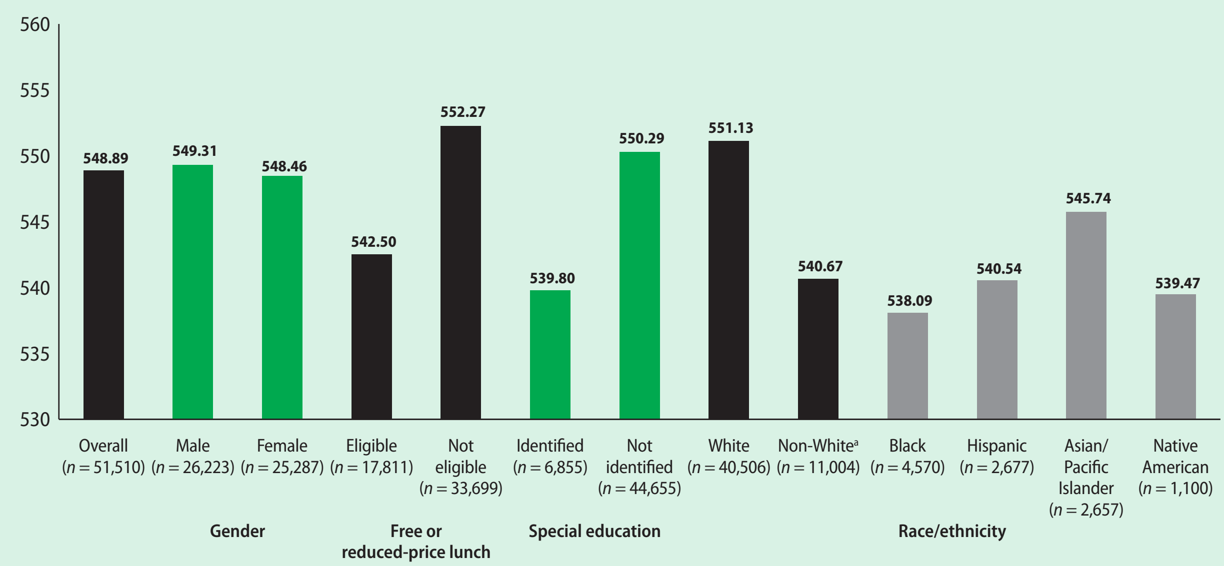
For both grades 5 and 8, medium to large differences were found in favor of students not identified for special education services, White students, and students not eligible for free or reduced-price lunch.[3] Students who were not identified for special education services scored 10.49 percentage points (effect size = 0.80) higher than students identified for special education services in grade 5 and 10.05 percentage points (effect size = 1.02) higher in grade 8.[4] Although gender gaps were statistically significant for both grades, the differences were substantively small. Male students scored 0.85 percentage point (effect size = 0.06) higher than female students in grade 5 and 1.35 percentage points (effect size = 0.13) higher in grade 8. Students not eligible for free or reduced-price lunch scored 9.77 percentage points (effect size = 0.77) higher than eligible students in grade 5 and 7.37 percentage points (effect size = 0.75) higher in grade 8. White students scored 10.46 percentage points (effect size = 0.82) higher than non-White students in grade 5 and 7.25 percentage points (effect size = 0.73) higher in grade 8.

Differences in science achievement by school characteristics

Schoolwide science achievement tended to be higher in schools with a lower percentage of students eligible for free or reduced-price lunch, limited English proficient students, and students identified for special education services; a higher percentage of White students; and a higher prior-year average MCA–II math and reading

FIGURE 1

Grade 5 average Minnesota Comprehensive Assessment–Series II science scores, by student demographic characteristics, 2009/10



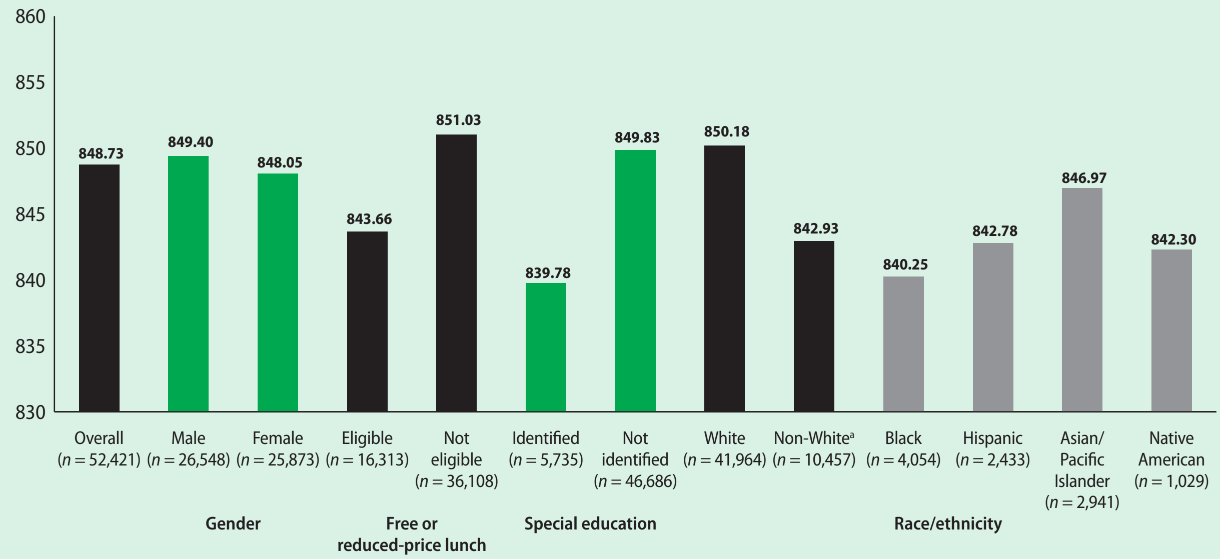
Note: This figure reports unadjusted scale-score averages. See appendix F for details on statistical significance.

a. Aggregates Black, Hispanic, Asian/Pacific Islander, and Native American students.

Source: Authors' analysis based on data from the Minnesota Department of Education.

FIGURE 2

Grade 8 average Minnesota Comprehensive Assessment–Series II science scores, by student demographic characteristics, 2009/10



Note: This figure reports unadjusted scale-score averages. See appendix F for details on statistical significance.

a. Aggregates Black, Hispanic, Asian/Pacific Islander, and Native American students.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE 1

Mean and standardized difference for grades 5 and 8 Minnesota Comprehensive Assessment–Series II science scores, 2009/10

Student characteristic	Grade 5	Grade 8
Gender		
Mean difference between male and female students	0.85***	1.35***
Standardized difference	0.06	0.13
Free or reduced-price lunch		
Mean difference between eligible and not eligible students	–9.77***	–7.37***
Standardized difference	–0.77	–0.75
Special education status		
Mean difference between students identified for services and not identified	–10.49***	–10.05***
Standardized difference	–0.80	–1.02
Race/ethnicity		
Mean difference between White and non-White students	10.46***	7.25***
Standardized difference	0.82	0.73

*** Statistically significant at the 0.001 level.

Note: This table reports unadjusted scale-score averages in the direction of the first subgroup listed for each characteristic for 51,510 students in grade 5 and 52,421 students in grade 8. Standardized differences were calculated using Cohen's *d* (see box 2). Significance test results come from two-tailed *t*-tests comparing subgroup averages using a two-level regression model that adjusts for student clustering within schools (see table F1 in appendix F).

Source: Authors' analysis based on data from the Minnesota Department of Education.

achievement score. These results were statistically significant and consistent across grades 5 and 8. For grade 8, schoolwide science achievement tended to be higher in schools with a higher percentage of female students, but for grade 5 the relationship was not statistically significant. The relationship between each of the school characteristics based on student composition and average school science achievement was consistent with the average differences in student achievement for each related demographic characteristic. The exception was for gender in grade 8, as mentioned.[5]

Schoolwide teacher characteristics were also related to schoolwide science achievement. Schoolwide science achievement tended to be higher in schools with more experienced faculty, with a higher percentage of teachers with an advanced degree, and with higher school student–teacher ratios.[6] These results were statistically significant and consistent across grades.

Variation in science achievement within and between schools

Consistent with Konstantopoulos (2006), this study found that the variation in performance on the MCA–II science assessment was due largely to differences among students within schools. More than 75 percent of the variation in student science scores (79.2 percent in grade 5 and 84.1 percent in grade 8) was due to differences among students within schools (see appendix E for more details). Differences between schools accounted for the remaining variation (20.8 percent in grade 5 and 16.0 percent in grade 8). After accounting for the influence of school-level characteristics based on student composition, differences in school characteristics explained less than 3 percent of the variation in science scores between schools. The school characteristics based on student composition that were significantly associated with science achievement were the percentage of students eligible for free or reduced-price lunch and the percentage of White students.

Between-school variation. Achievement differences between schools were explained primarily by differences in the student population. Together, student demographics and prior-year academic achievement explained 79.7 percent of the variation in science scores between schools in grade 5 and 82.1 percent in grade 8. After accounting for

TABLE 2

Correlation between schoolwide Minnesota Comprehensive Assessment–Series II science scores and school characteristics for grades 5 and 8, 2009/10

School characteristic	Pearson correlation coefficient: Grade 5 (*n* = 786)	Pearson correlation coefficient: Grade 8 (*n* = 469)
Percentage of female students	0.02	0.26***
Percentage of students eligible for free or reduced-price lunch	–0.74***	–0.75***
Percentage of limited English proficient students[a]	–0.45***	–0.34***
Percentage of students identified for special education services	–0.21***	–0.46***
Percentage of White students	0.65***	0.58***
Years of teaching experience	0.22***	0.22***
Percentage of full-time equivalent credits taught by teachers with an advanced degree	0.15***	0.20***
Student–teacher ratio	0.22***	0.23***
Prior year's Minnesota Comprehensive Assessment–Series II math and reading composite score	0.86***	0.88***

*** Statistically significant at the 0.001 level.

a. Includes results for limited English proficient students because school-level percentages for this student subgroup were not affected by the missing data.

Source: Authors' analysis based on data from the Minnesota Department of Education.

the influence of individual student characteristics, school characteristics based on student composition and teacher composition together explained 2.1 percent of the differences in science achievement between schools in grade 5 and 2.7 percent in grade 8.

However, only a limited set of school characteristics was available in the data. A portion of the variance between schools (18.3 percent in grade 5 and 15.2 percent in grade 8) is not explained by variables in this study and might be due to unobserved student and school characteristics (for example, science teachers' quality of teaching) and random error.[7]

Associations between student science achievement and school characteristics based on student composition. After the influence of individual student characteristics was accounted for, two school characteristics had a statistically significant association with achievement in both grades: the percentage of students eligible for free or reduced-price lunch and the percentage of White students (see table E2 in appendix E).[8] The percentages of female students,[9] students identified for special education services, and average prior-year academic achievement were not significant predictors of science achievement.

If all other factors remained the same, the results suggest the following:

- *Percentage of students eligible for free or reduced-price lunch.* A 1 percentage point increase in the percentage of students eligible for free or reduced-price lunch in a school was associated with an estimated decrease in student science scores of 2.3 percentage points in grade 5 and 2.7 percentage points in grade 8.

- *Percentage of White students.* A 1 percentage point increase in the percentage of White students was associated with an estimated 3.2 percentage point increase in student science achievement in grade 5 and a 2.3 percentage point increase in grade 8.

Associations between student science achievement and teacher characteristics. After the influence of individual student characteristics and school-level characteristics based on student composition were accounted for, none of the teacher-related school characteristics examined in this study (years of experience, percentage of teachers with an advanced degree, student–teacher ratio) was related to grade 5 or grade 8 student science achievement.

After the influence of individual student characteristics was accounted for, two school characteristics had a statistically significant association with achievement in both grades: the percentage of students eligible for free or reduced-price lunch and the percentage of White students

STUDY LIMITATIONS

The current study has several limitations. First, the associations of student and school characteristics with achievement are based on correlation analysis, so causality cannot be inferred. The analysis shows how student science performance differs by student characteristic (such as gender and race/ethnicity) and school characteristic (such as the percentage of students eligible for free or reduced-price lunch). It cannot show, however, that being female, for instance, "causes" a student to perform at a certain level. Rather, these findings provide a snapshot of overall patterns of achievement and identify demographic subgroups that are at risk for poor performance in science and that could benefit from more intensive support in science education.

Second, private school students and students who took alternative assessments are not included in the analysis, and therefore the conclusions apply only to the public, charter, and magnet school students who took the MCA–II in 2009/10.

Third, the study included only nine school characteristics, none directly related to the science instruction. For example, the teacher-related school characteristics included information based on all teachers, not science teachers specifically. Minnesota is developing a system for capturing course data; future research could use these data to look for an association between coursework and other teacher- and school-related characteristics and student achievement on the MCA–II.

Fourth, the school characteristics based on student composition were for an entire school, not just for grade 5 or grade 8. The results differed somewhat when student percentages and schoolwide percentages were examined for a given grade instead, but most differences were less than 5 percent (see table F2 in appendix F).

After accounting for student characteristics, school factors explained little of the variation between schools in science achievement in 2009/10

Fifth, students with missing data for either student or school characteristics were not included in the analyses. In most cases, the students were removed because of missing data on prior-year academic achievement. Students with missing data differ in some respects from those without missing data, so the results cannot be generalized to students who were not included in the analyses. For some subgroups, such as limited English proficient students and students identified for special education services, more than 20 percent of students were excluded from the analyses because of missing data. Further analysis (reported in appendix F) indicated that limited English proficient students who were excluded from the study due to missing data differed significantly from students who were included on the MCA–II and demographic characteristics. Thus, conclusions about limited English proficient students cannot be drawn, and findings for these students were not discussed in this report.

CONCLUSIONS

This report aims to provide Minnesota policymakers with insight into factors related to science achievement, as measured by the MCA–II. Although differences in science achievement by student demographic characteristics have been well documented, the current study is the first to look comprehensively at student characteristics and scores on the MCA–II science assessment. Using 2009/10 data, the study found medium to large statistically significant differences in average science achievement for grades 5 and 8 favoring students not identified for special education services, students not eligible for free or reduced-price lunch, and White students. Small differences were found favoring male students. The results related to gender, eligibility for free or reduced-price lunch, and race/ethnicity are consistent with those of previous research using national samples (Gonzales et al. 2008; Konstantopoulos 2006; National Assessment of Educational Progress n.d.).

Beyond student characteristics, the limited set of school factors examined here do not seem to influence science achievement. While correlation analysis showed associations between schoolwide science achievement and school characteristics based on student and teacher composition, these relationships mostly disappeared after accounting for student characteristics. Moreover, after accounting for student characteristics, school factors explained little of the variation between schools in science achievement in 2009/10, which is consistent with findings from Stewart (2008) and Konstantopoulos (2006). Although some studies have found significant relationships between teacher characteristics and student achievement (Finn and Achilles 1990; Krueger and Whitmore 2001; McGiverin et al. 1989; Nyhan and Alkadry 1999), the current study was consistent with Konstantopoulos (2006) in finding no significant relationship between the student–teacher ratio and achievement. In the current study, teacher characteristics explained less than 1 percent of the differences in school achievement between schools, and the teacher characteristics were not statistically significant.

Future work could examine the effects of school characteristics specifically related to science instruction, such as course and program offerings, science teacher performance, science teacher preparation and experience, and resources to support science instruction.

APPENDIX A
MINNESOTA K–12 ACADEMIC STANDARDS IN SCIENCE

This appendix lists the Minnesota K–12 academic standards in science, as enumerated in Minnesota Department of Education (2009a).

Strand 1: Nature of Science and Engineering

- Substrand 1: The Practice of Science
  - Standard 1. Understandings about science
  - Standard 2. Scientific inquiry and investigation

- Substrand 2: The Practice of Engineering
  - Standard 1. Understandings about engineering
  - Standard 2. Engineering design

- Substrand 3: Interactions among Science, Technology, Engineering, Mathematics, and Society
  - Standard 1. Systems
  - Standard 2. Careers and contributions in science and engineering
  - Standard 3. Mutual influence of science, engineering, and society
  - Standard 4. The role of math and technology in science and engineering

Strand 2: Physical Science

- Substrand 1: Matter
  - Standard 1. Properties and structure of matter
  - Standard 2. Changes in matter

- Substrand 2: Motion
  - Standard 1. Describing motion
  - Standard 2. Forces

- Substrand 3. Energy
  - Standard 1. Kinds of energy
  - Standard 2. Energy transformations

- Substrand 4. Human Interactions with Physical Systems
  - Standard 1. Interaction with the environment

Strand 3: Earth and Space Science

- Substrand 1. Earth Structure and Processes
  - Standard 1. Plate tectonics
  - Standard 2. Earth's changing surface
  - Standard 3. Rock sequences and Earth history

- Substrand 2. Interdependence within the Earth System
  - Standard 1. Sources and transfer of energy
  - Standard 2. Weather and climate
  - Standard 3. Materials cycles

- Substrand 3. The Universe
  - Standard 1. Solar system motion
  - Standard 2. Formation of the solar system
  - Standard 3. Age, scale, and origin of the universe

- Substrand 4. Human Interactions with Earth Systems
  - Standard 1. Interaction with the environment

Strand 4: Life Science

- Substrand 1. Structure and Function in Living Systems
  - Standard 1. Levels of organization
  - Standard 2. Cells

- Substrand 2. Interdependence among Living Systems
  - Standard 1. Ecosystems
  - Standard 2. Flow of energy and matter

- Substrand 3. Evolution in Living Systems
  - Standard 1. Reproduction
  - Standard 2. Variation
  - Standard 3. Biological evolution

- Substrand 4. Human Interactions with Living Systems
  - Standard 1. Interaction with the environment
  - Standard 2. Health and disease

APPENDIX B
DATA PROCEDURES

This appendix describes the study's data sources and analysis procedures.

Data sources

For restricted-use data, a formal request was placed with the Minnesota Data Compliance Department; a data-sharing agreement under the Family Educational Rights and Privacy Act was created and signed to allow access to the data. The data were transmitted through a secure site maintained by the Minnesota Department of Education. To protect student confidentiality, data were provided with unique student identifying codes rather than student names. These student identifiers were used to link student records in the demographic data and assessment files. Only authorized research personnel had access to the data. Public-use files were obtained from the Minnesota Department of Education website.

Restricted-use data files. The Minnesota Department of Education provided two restricted-use student data files (with grade 5 and grade 8 information combined; figure B1). The first file contained student demographic data—gender, eligibility for free or reduced-price lunch, limited English proficiency status, special education status, and race/ethnicity—collected in the fall of a given school year and updated when a student had a change in free or reduced-price lunch eligibility, limited English proficiency status, or special education status. If a student's status changed during the year, the most recent status was used in the analysis. These data were collected by the state as part of the Minnesota Automated Reporting Student System (MARSS). The second data file contained students' Minnesota Comprehensive Assessment–Series II (MCA–II) scores and demographic information (collected each spring with the administration of MCA–II science assessment). Pearson Assessments collects MCA–II student assessment data annually and provides the data to the Minnesota Department of Education.

Public-use data files. Public-use data files contained school characteristics based on student and teacher composition (see figure B1).

- School-level student demographic data included the percentages of female students, students eligible for free or reduced-price lunch, limited English proficient students, students identified for special education services, and White students.
- School-level student achievement data included current year (2009/10) MCA–II science scores and prior years' MCA–II composite math and reading scores.
- School-level teacher data included teacher experience (average years of teaching for teachers at each school), degree attainment (percentage of full-time equivalent credits taught by teachers with advanced degrees), and the student–teacher ratio (average number of students per teacher).

The public-use data files at the school level included all schools that had either a grade 5 or a grade 8. A few schools had both grades.

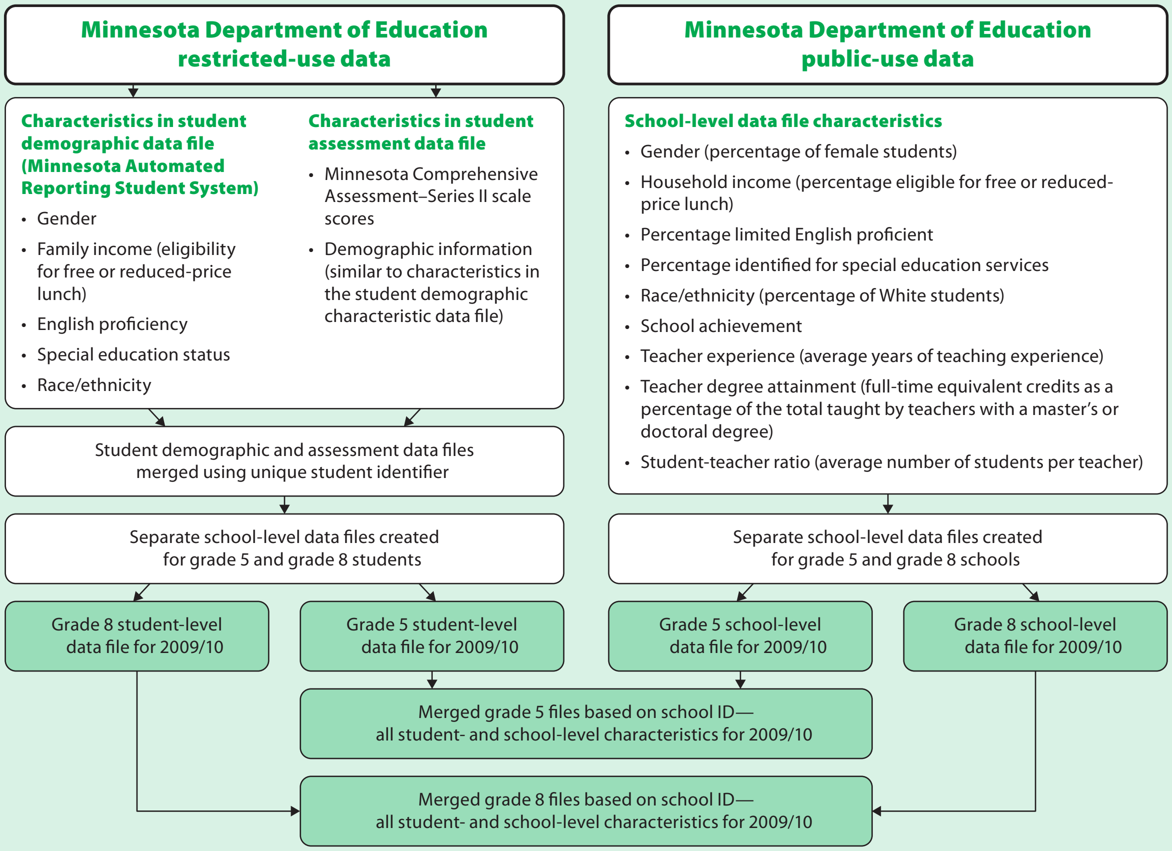
Data cleaning and merging

This section discusses how the two student record files were merged and how missing data were handled.

Student assessment and demographic files. Two student record files (containing assessment data and demographic data from the MARSS) were merged using unique student identifiers and district and school codes (see figure B1). Before the two files were merged, duplicate and missing demographic and test score data in the assessment file had to be resolved. In some cases, students had multiple rows in the assessment file—for example, because they had two sets of test scores. When there were multiple rows in the assessment file for a single student record, discrepancies were resolved using the following procedures:

FIGURE B1

Process for obtaining and merging Minnesota Department of Education data files



Note: Shaded boxes indicate points where data files were used to conduct data analyses.

- If all rows in the assessment file for the same student had demographic information, the demographic information was compared with the demographic data in the MARSS file. Data from rows with discrepant information were dropped. The demographic data in MARSS were used as the standard because those data are collected by schools and school districts and verified for accuracy by the state. In 2009/10, across both grades, fewer than 0.05 percent of cases in the assessment file had duplicate rows deleted because of discrepancies in demographic data.

- If all rows in the assessment file for the same student had demographic information and there was no discrepancy, the row with the highest MCA–II scale score was kept. In 2009/10 across both grades, fewer than 0.05 percent of cases had duplicate rows deleted after keeping the highest score.

- If some rows in the assessment file for the same student had missing demographic data, the row with available data that matched demographic data in the MARSS was kept. Discrepancies and missing data for gender and race/ethnicity were examined before the other demographic characteristics. In 2009/10 across both grades, 0.02 percent of students had discrepancies for gender, and 0.51 percent of students were missing data on gender in one source; 0.37 percent of students had discrepancies for race/ethnicity, and 0.60 percent of students were missing data on race/ethnicity in one source.

Missing data. Analyses were performed on complete cases only. After student demographic and assessment files were merged, any student cases missing one of the key variables—MCA–II science scale scores, student demographic information, student prior-year math and reading scale scores, or school covariates—were deleted manually.

Table B1 shows the total number of students in the files received from the Minnesota Department of Education after duplicate values were reconciled, as well as the number of students excluded because of missing data. Less than 2 percent of students were missing MCA–II science scores; most of these students were identified for special education services or took alternative assessments (such as the Minnesota Test of Academic Skills, a test administered to students with significant cognitive impairments) or both. MCA–II science score data were not imputed for students who took alternative assessments because these students were deemed better served by alternative assessments or for the remaining students (less than 2 percent of the total excluded) because the percentage of missing data was so small. Next, students who were missing data for at least one demographic characteristic (less than 1 percent of the samples) were deleted. Demographic data such as gender were not imputed at the student level because there is no logical way to impute someone's gender.

TABLE B1

Number of students with missing data and percentage of the original sample for grades 5 and 8, 2009/10

	Grade 5		Grade 8	
Characteristic	Number of students with missing data	Percentage of original sample (*n* = 59,311)	Number of students with missing data	Percentage of original sample (*n* = 59,564)
Student characteristics				
Minnesota Comprehensive Assessment–Series II science scores	941	1.6	1,002	1.7
Student demographic data (gender, free or reduced-price lunch eligibility, special education status, limited English proficiency status, and race/ethnicity)	286	0.5	493	0.8
Prior-year academic achievement	5,005	8.4	3,760	6.3
School characteristics				
Student-related (percentage of females, students eligible for free or reduced-price lunch, students identified for special education services, limited English proficient students, and White students)	0	0.00	83	0.14
School average prior-year academic achievement[a]	1,617	2.7	2,106	3.5
Teacher-related (years of experience, teacher degree attainment,[b] and student–teacher ratio)	157	0.26	76	0.13
Students whose data were deleted[c]	7,801	13.2	7,143	12.0
Analytic sample for questions 1 and 3	51,510	86.9	52,421	88.0

Note: Components might not sum to totals because of rounding.

a. Prior-year (grade 4 for grade 5 and grade 7 for grade 8) school average Minnesota Comprehensive Assessment–Series II math and reading composite score.

b. The percentage of full-time equivalent credits taught by teachers with a master's or doctoral degree.

c. Total deleted is not equal to the sum of previous rows because some students were missing data for multiple characteristics.

Source: Authors' analysis based on data from the Minnesota Department of Education.

Prior-year academic achievement data on the MCA–II math and reading assessments (a composite score) in grades 4 and 7 were missing for 8.4 percent of students in grade 5 and 6.3 percent of students in grade 8, respectively. Missing data were not imputed because more than half the students (2,705 of 5,005) with missing prior-year academic achievement scores were also missing either their math or reading scores for the current year, a key covariate for improving the reliability of the imputation procedure.

After students with missing demographic data were excluded, the student-level files were merged with the school-level files. This consolidated data file included each student and the characteristics of a given student's school. Some schools did not have data for certain characteristics. Because missing school-level data across all school characteristics (other than prior-year academic achievement) for both grades 5 and 8 never totaled more than 2.4 percent, complete case analysis was used instead of data imputation. Less than 4 percent of students were missing school average prior-year academic achievement (2.73 percent in grade 5 and 3.54 percent in grade 8), less than 0.30 percent of students were missing teacher-related characteristics (0.26 percent in grade 5 and 0.13 percent in grade 8), and less than 0.20 percent of students were missing student-related school characteristics (0.00 percent in grade 5 and 0.14 percent in grade 8). Overall, the total percentage of students excluded because of missing data was 13.15 percent in grade 5 and 11.99 percent in grade 8.

Data characteristics and special coding

The statistical analysis programs SAS and SPSS (Statistical Package for the Social Sciences) were used to code and aggregate raw data to create the characteristics shown in table B2. This section discusses the data on characteristics that were ready to analyze as obtained and those that required manipulation before they could be analyzed.

Student achievement. Current-year (2009/10) grade 5 and grade 8 MCA–II science scale scores needed no data manipulation when acquired from the Minnesota Department of Education. The study used scores only from students who completed the MCA–II science assessment. Students who took alternative state tests (such as the Minnesota Test of Academic Skills) were excluded from the analyses on MCA–II science outcomes because the two forms could not be equated.

Since math and reading test scores are likely to be highly correlated, a composite measure of prior-year academic achievement was calculated and used. For students within each grade, the prior year MCA–II math and reading scale scores were standardized separately (by subtracting the grade mean and dividing by grade standard deviation), added together, and then restandardized to form the composite score.

School characteristics. For each school, the Minnesota Department of Education website provides data on the school characteristics shown in table B2. With the exception of the prior-year school average math and reading composite score, the school characteristics are for an entire school, not just for grade 5 or 8. The prior-year school average achievement was calculated by standardizing the average of the prior-year MCA–II math and reading scores of current year grade 5 or grade 8 students included in the analytic samples, summing the standardized math and reading scores separately for each grade, and then standardizing them again.

The Minnesota Department of Education provided teacher degree attainment measured as the number of full-time equivalent (FTE) credits taught by teachers with each type of degree (less than a bachelor's degree, bachelor's degree, master's degree, or doctoral degree) at the school level. FTE credits represent the amount of time per week an individual is reported in a teaching assignment. To obtain a single continuous characteristic, the FTE credits taught by teachers with a master's or doctoral degree were divided by the total number of FTE credits for a school across all degree types. This new characteristic represented the percentage of FTE credits taught by teachers with an advanced degree. Master's level

TABLE B2
Data elements, coding, and use

Data element	Data coding	Data use
Unique student identifier	Unique student number assigned by the state (no coding needed)	Unique record ID
Race/ethnicity	5 = White; 4 = Black; 3 = Hispanic; 2 = Asian/Pacific Islander; 1 = Native American	Demographic characteristic analysis
White/non-White[a]	0 = White; 1 = non-White	Demographic characteristic analysis; multilevel model
Gender	0 = male; 1 = female	Demographic characteristic analysis; multilevel model
Free or reduced-price lunch indicator	1 = eligible for free or reduced-price lunch; 0 = not eligible for free or reduced-price lunch	Demographic characteristic analysis; multilevel model
Special education status	1 = special education identification; 0 = no special education identification	Demographic characteristic analysis; multilevel model
Limited English proficiency	1 = limited English proficient; 0 = not limited English proficient	Multilevel model
Grade 5 and grade 8 MCA–II scale scores	Scale scores for math, reading, and science, used as provided	Demographic characteristic analysis; multilevel model
Unique school identifier	Combined the school number and district number to create a unique identifier[b]	Correlation analysis; multilevel model
School name	No coding for this characteristic, just a display of each school name	Correlation analysis; multilevel model
Gender	Percentage of female students	Correlation analysis; multilevel model
Free or reduced-price lunch indicator	Percentage of students eligible for free or reduced-price lunch	Correlation analysis; multilevel model
Special education status	Percentage of students identified for special education services	Correlation analysis; multilevel model
Limited English proficiency	Percentage of limited English proficient students	Correlation analysis; multilevel model
Race/ethnicity	Percentage of White students	Correlation analysis; multilevel model
School achievement	School average scale scores on the Minnesota Comprehensive Assessment–Series II math and reading tests (two scale scores combined to form a composite score) and average science scale scores	Correlation analysis; multilevel model
Teacher experience	Average years of total teaching experience for all teachers in each school	Correlation analysis; multilevel model
Teacher degree attainment	For each school, the percentage of full-time equivalent credits taught by teachers with a master's or doctoral degree relative to all full-time equivalent credits taught at each school	Correlation analysis; multilevel model
Student–teacher ratio	Average student–teacher ratio at each school	Correlation analysis; multilevel model

a. Constructed characteristic. Non-White includes Black, Hispanic, Asian/Pacific Islander, and Native American students.

b. Districts assign numbers to their schools, but they are not unique across districts. Therefore, combining the district and school numbers created a unique school ID.

Source: Minnesota Department of Education public-use school-level data.

and higher was chosen because the goal was to represent higher degree levels among teachers (most teachers had earned a bachelor's degree). Student performance was hypothesized to relate to teachers' education attainment based on research by Hogrebe et al. (2008) and Goldhaber and Brewer (1996).

APPENDIX C
STUDENT DEMOGRAPHIC AND SCHOOL CHARACTERISTICS FOR GRADES 5 AND 8

This appendix includes tables showing the sample size of demographic subgroups and correlations among school characteristics for grades 5 and 8.

TABLE C1

Grade 5 sample size and percentage of students relative to the original student population, by student characteristic, 2009/10

Demographic characteristic and subgroup	Number of students		Percentage of original sample
	Analytic sample	Original population[a]	
All students	51,510	59,311	86.9
Gender			
Male	26,223	30,784	85.2
Female	25,287	28,784	87.9
Free or reduced-price lunch			
Eligible	17,811	22,386	79.6
Not eligible	33,699	36,633	92.0
English proficiency			
Limited	2,025	4,991	40.6
Not limited	49,485	54,311	91.1
Special education status			
Identified	6,855	8,959	76.5
Not identified	44,655	50,060	89.2
Race/ethnicity			
White	40,506	43,971	92.1
Non-White	11,004	15,048	73.1
Black	4,570	5,825	78.5
Hispanic	2,677	4,232	63.3
Asian/Pacific Islander	2,657	3,751	70.8
Native American	1,100	1,240	88.7

a. For each demographic characteristic, the sum of the subgroup sample sizes (for example, male students plus female students) does not sum to the total number of students (59,311 in this example) because some students had missing values for some demographic characteristics.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE C2

Correlation among school characteristics for the 786 schools included in the grade 5 analytic sample

School characteristic	Percentage White	Percentage female	Percentage eligible for free or reduced-price lunch	Percentage identified for special education services	Percentage limited English proficient	Teacher experience	Teacher degree	Student–teacher ratio	Math and reading composite score[a]
Percentage White	1.00								
Percentage female	–0.03	1.00							
Percentage eligible for free or reduced-price lunch	–0.73***	0.04	1.00						
Percentage identified for special education services	–0.02	–0.27***	0.28***	1.00					
Percentage limited English proficient	–0.78***	–0.01	0.59***	–0.15***	1.00				
Teacher experience	0.30***	–0.04	–0.16***	0.15***	–0.25***	1.00			
Teacher's degree	–0.12***	–0.01	–0.26***	–0.26***	0.12***	0.13***	1.00		
Student–teacher ratio	0.11***	0.10*	–0.32***	–0.35***	–0.11***	0.01	0.25***	1.00	
Math and reading composite score[a]	0.58***	0.02	–0.75***	–0.28***	–0.40***	0.18***	0.19***	0.21***	1.00

* Statistically significant at the 0.05 level; *** statistically significant at the 0.001 level.

a. Composite score on the Minnesota Comprehensive Assessment–Series II reading and math tests.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE C3

Grade 8 sample size and percentage of students relative to the original student population, by student characteristic, 2009/10

Demographic characteristic and subgroup	Number of students		Percentage of the original sample
	Analytic sample	Original population[a]	
All students	52,421	59,564	88.0
Gender			
Male	26,548	30,211	87.9
Female	25,873	28,913	89.5
Free or reduced-price lunch			
Eligible	16,313	20,151	81.0
Not eligible	36,108	38,898	92.8
English proficiency			
Limited	1,577	3,502	45.0
Not limited	50,844	55,547	91.5
Special education status			
Identified	5,735	7,618	75.3
Not identified	46,686	51,431	90.8
Race/ethnicity			
White	41,964	45,504	92.2
Non-White	10,457	13,545	77.2
Black	4,054	5,212	77.8
Hispanic	2,433	3,444	70.6
Asian/Pacific Islander	2,941	3,696	79.6
Native American	1,029	1,193	86.3

a. For each demographic characteristic, the sum of the subgroup sample sizes (for example, male students plus female students) does not sum to the total number of students (59,564 in this example) because some students had missing values for some demographic characteristics.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE C4

Correlation among school characteristics for the 469 schools included in the grade 8 analytic sample

School characteristic	Percentage White	Percentage female	Percentage eligible for free or reduced-price lunch	Percentage identified for special education services	Percentage limited English proficient	Teacher experience	Teacher degree	Student–teacher ratio	Math and reading composite score[a]
Percentage White	1.00								
Percentage female	0.05	1.00							
Percentage eligible for free or reduced-price lunch	–0.75***	–0.17***	1.00						
Percentage identified for special education services	–0.17***	–0.58***	0.35***	1.00					
Percentage limited English proficient	–0.73***	0.05	0.57***	–0.07	1.00				
Teacher experience	0.36***	0.03	–0.21***	–0.11*	–0.26***	1.00			
Teacher's degree	–0.12*	0.05	–0.20***	–0.04	0.09*	0.08	1.00		
Student–teacher ratio	–0.03	0.26***	–0.20***	–0.33***	0.03	–0.03	0.23***	1.00	
Math and reading composite score[a]	0.45***	0.33***	–0.69***	–0.53***	–0.25***	0.19***	0.25***	0.31***	1.00

* Statistically significant at the 0.05 level; *** statistically significant at the 0.001 level.

a. Composite score on the Minnesota Comprehensive Assessment–Series II reading and math tests.

Source: Authors' analysis based on data from the Minnesota Department of Education.

APPENDIX D
DATA ANALYSIS

This appendix describes the data analysis for each research question.

Research question 1

For each grade, Minnesota Comprehensive Assessment–Series II (MCA–II) science assessment score averages were calculated for the entire sample and by demographic characteristic (such as gender and race/ethnicity). Differences in average MCA–II scale scores between subgroups were also calculated. For a more nuanced look at the magnitude of differences in averages, standardized average differences or effect sizes (Cohen's *d*; Cohen 1988) were also reported. *T*-tests were conducted to examine the statistical significance of the differences in average scores between demographic subgroups. Reported *t*-test statistics and *p*-values were corrected for clustering, using a two-level multilevel model with a random intercept and with the demographic characteristic of interest as the only predictor.

Research question 2

Pearson correlations were calculated between school-level average performance on the MCA–II science assessment and school characteristics based on student and teacher composition.

Research question 3

Two-level multilevel models, with students nested in schools, were run to predict student-level achievement on the MCA–II science assessment for grades 5 and 8 separately. Stata and the lme4 software package in R were used for the analyses (Bates, Maechler, and Bolker 2011).

For each grade, five models were estimated in three stages. In the first stage, an unconditional model (which did not include any student- or school-level characteristics) was estimated to establish the amount of within- and between-school variance in student science achievement (model 1). In the following stages, student- and school-level characteristics were added in blocks to discern how much variation student- and school-level characteristics explained. In the second stage, model 2 included student gender, eligibility for free or reduced-price lunch, special education status, limited English proficiency status, and race/ethnicity (White/non-White). Model 3 added prior-year academic achievement. In the third stage, school-level characteristics were added. Model 4 added school-level student characteristics: the percentages of female students, students eligible for free or reduced-price lunch, limited English proficient students, students identified for special education services, and White students, plus prior-year school average composite math and reading achievement. Model 5 added school-level teacher characteristics: teacher experience, teacher degree attainment, and student–teacher ratio. Models in the third stage estimated the relationship between school-level characteristics and science achievement, after accounting for the influence of student-level characteristics.

The study used grand-mean centering for all variables (continuous and categorical) in the analysis for research question 3 because its principal aim was to estimate the influence of school characteristics (level-2 predictors) on student science achievement after accounting for the influence of student characteristics. Grand-mean centering of both student- and school-level characteristics established meaningful intercepts and slopes that allowed level-2 predictors to account for between-school differences (Enders and Tofighi 2007). Categorical characteristics were dummy-coded using one of the categories as a reference category (for example, 0 = male and 1 = female) prior to centering.

The final specification of the model was as follows:

Level 1: students within schools

$$Y_{ij} = \pi_{0j} + \Sigma\pi_{pj}X_{pij} + e_{ij}$$

where Y_{ij} = either grade 5 or grade 8 score on the MCA–II science assessment of student i in school j; π_{0j} = estimated average MCA–II science score for school j adjusted for student characteristics X_{pij}; π_{pj} = estimated association between MCA–II science score and X_{pij} adjusted for other student characteristics; X_{pij} = pth student characteristic (see table B2 in appendix B) for student i in school j (grand-mean centered); and e_{ij} = random error term for student i in school j.

Level 2: schools

$$\pi_{0j} = \beta_{00} + \Sigma\beta_{0q}W_{qj} + r_{0j}$$
$$\pi_{pj} = \beta_{p0}$$

where β_{00} = expected average school mean MCA–II science score (in grade 5 or 8) across all schools; β_{0q} = expected average difference in school mean MCA–II science score associated with one unit difference in W_{qj}, adjusted for other school-level characteristics; W_{qj} = school characteristic q for school j (grand-mean centered); r_{0j} = school-level random error term; and β_{p0} = expected average difference in MCA–II science score associated with one unit difference in X_{pij} adjusted for other student characteristics.

APPENDIX E VARIANCE DECOMPOSITION FROM MULTILEVEL MODELS

This appendix describe the amount of variation in student achievement explained by five multilevel models, beginning with a baseline model with no student or school characteristics (model 1) and successively adding student characteristics (models 2 and 3) and school characteristics (models 4 and 5). See Table E1 for details.

- *Model 1: overall variation in achievement.* Most of the variation in student science scores in 2009/10 (79.2 percent in grade 5 and 84.1 percent in grade 8) was due to differences among students in the same schools (within-school variance).[10] Differences between schools accounted for the remaining variation in student science achievement (20.8 percent in grade 5 and 16.0 percent in grade 8).
- *Models 2 and 3: differences in achievement between schools explained by student characteristics.* The differences between schools in science achievement were due primarily to differences in the kinds of students who attended different schools. Individual student demographics,

TABLE E1

Multilevel models and the percentages of between-school variance in grades 5 and 8 student science achievement explained

Model	Block of characteristics added	Characteristics included in each block	Estimated percentage of between-school variance: Grade 5	Grade 8
1	Unconditional model	—	20.76	15.95
			Estimated percentage of between-school variance explained: Grade 5	Grade 8
2	Student demographic characteristics	• Gender • Eligibility for free or reduced-price lunch • Limited English proficiency status • Special education status • Race/ethnicity (White/non-White)	57.5	58.0
3	Student prior-year academic achievement	• Grade 4 or grade 7 Minnesota Comprehensive Assessment–Series II (MCA–II) math and reading composite score	22.2	24.2
Between-school variance explained by models 2 and 3			79.7	82.1
4	School characteristics based on student composition	• School student demographic variables[a] • School average grade 4 or grade 7 MCA–II math and reading composite score	2.1	2.7
5	School characteristics based on teacher composition	• Teacher years of experience • Degree attainment • Student–teacher ratio	–0.01[b]	0.00
Between-school variance explained by models 4 and 5			2.1	2.7
Total between-school variance explained by model 5			81.7	84.9

Note: The within-school variance for model 1 is not shown because the focus of this section is on differences between schools. Components might not sum to totals because of rounding.

a. School characteristics based on student composition included in model 4 are the percentages of female students, students eligible for free or reduced-price lunch, limited English proficient students, students identified for special education services, and White students.

b. When fixed effects are added to a multilevel model, small decreases (less than 5 percent) and even negative variance in the proportion of variance explained can occur by chance. Larger decreases might signal possible model misspecification (Snijders and Bosker 1999).

Source: Authors' analysis based on data from the Minnesota Department of Education.

added in model 2, and student prior-year academic achievement, added in model 3, together explained 79.7 percent of the variation in grade 5 and 82.1 percent in grade 8.

- *Models 4 and 5: differences in achievement between schools explained by school characteristics.* After the influence of student characteristics (entered in models 2 and 3) was accounted for, school characteristics explained a small portion of the overall variation in performance on the science assessment. School characteristics based on student composition, added in model 4, and teacher characteristics, added in model 5, together explained 2.1 percent of the variation in grade 5 and 2.7 percent in grade 8.

TABLE E2

Grades 5 and 8 multilevel model regression coefficients and standard errors for the full model (model 5)

Characteristic	Grade 5	Grade 8
Student characteristics		
Female	–2.00*** (0.07)	–2.62*** (0.05)
Eligible for free or reduced-price lunch	–0.94*** (0.09)	–0.55*** (0.07)
Identified for special education services	–1.10*** (0.11)	–0.20* (0.09)
Limited English proficient	–3.02*** (0.23)	–1.75*** (0.19)
White	2.29*** (0.11)	1.62*** (0.08)
Prior-year academic achievement[a]	9.49*** (0.04)	7.85*** (0.03)
School characteristics		
Percentage of female students	5.27 (2.97)	2.27 (2.43)
Percentage of students eligible for free or reduced-price lunch	–2.33* (1.02)	–2.65** (.91)
Percentage of students identified for special education services	3.65 (2.58)	–1.68 (1.40)
Percentage of limited English proficient students[b]	4.38*** (1.17)	2.88*** (1.07)
Percentage of White students	3.24*** (0.83)	2.31*** (0.72)
School average teacher experience	0.02 (0.03)	–0.02 (0.03)
Percentage of full-time equivalent credits taught by teachers with advanced degrees	0.00 (0.01)	0.01 (0.00)
Student–teacher ratio	0.05 (0.03)	0.00 (0.02)
School average prior-year academic achievement[c]	0.19 (0.38)	–0.57 (0.34)

* Statistically significant at the 0.05 level; ** statistically significant at the 0.01 level; *** statistically significant at the 0.001 level.

Note: Numbers in parentheses are standard errors.

a. Prior-year (grade 4 or grade 7) student Minnesota Comprehensive Assessment–Series II (MCA–II) math and reading composite score.

b. Because of missing data, more than 50 percent of limited English proficient students were removed from the sample. Those that remained were not representative of all limited English proficient students, which could lead to biased results for the comparison of limited English proficient and non–limited English proficient students.

c. Prior-year (grade 4 or grade 7) school average MCA–II math and reading composite score.

Source: Authors' analysis based on data from the Minnesota Department of Education.

APPENDIX F ADDITIONAL ANALYSES

This appendix presents the results of additional analyses. Table F1 shows the *t*-statistics and *p*-values associated with subgroup differences for research question 1. Table F2 shows the differences between student- and school-level data. Tables F3–F6 provide more detail on missing data for limited English proficient students.

TABLE F1

Grades 5 and 8 significance test results for research question 1

	Grade 5		Grade 8	
Student characteristic	Mean difference	*p*-value	Mean difference	*p*-value
Female	–0.85 (0.11)	< 0.001	–1.39 (0.09)	< 0.001
Eligible for free or reduced-price lunch	–7.41 (0.12)	< 0.001	–5.82 (0.10)	< 0.001
Identified for special education services	–9.92 (0.16)	< 0.001	–9.47 (0.13)	< 0.001
White	8.10 (0.15)	< 0.001	6.01 (0.12)	< 0.001
Race/ethnicity pairwise comparisons				
Native American–Asian/Pacific Islander	–4.78 (0.49)	< 0.001	–3.49 (0.38)	< 0.001
Native American–Hispanic	–0.23 (0.48)	1.000	0.43 (0.38)	1.000
Native American–Black	1.82 (0.46)	0.001	3.21 (0.36)	< 0.001
Native American–White	–8.67 (0.42)	< 0.001	–5.66 (0.33)	< 0.001
Asian/Pacific Islander–Hispanic	4.55 (0.35)	< 0.001	3.92 (0.27)	< 0.001
Asian/Pacific Islander–Black	6.60 (0.31)	< 0.001	6.70 (0.24)	< 0.001
Asian/Pacific Islander–White	–3.90 (0.26)	< 0.001	–2.17 (0.20)	< 0.001
Hispanic–Black	2.05 (0.31)	< 0.001	2.78 (0.25)	< 0.001
Hispanic–White	–8.44 (0.26)	< 0.001	–6.09 (0.21)	< 0.001
Black–White	–10.49 (0.22)	< 0.001	–8.87 (0.17)	< 0.001

Note: Numbers in parentheses are standard errors. The mean differences are estimated using a two-level multilevel model, which adjusts for clustering. The *p*-values are based on a two-tailed *t*-test of difference between means. Before conducting *t*-tests of pairwise differences in averages between racial/ethnic group, an overall *F*-test was conducted of equality of averages adjusted for clustering. There was a statistically significant overall difference among the five racial/ethnic group for both grade 5 ($F = 814.57$, $p < 0.001$) and grade 8 ($F = 830.48$, $p < 0.001$). The *p*-values for the pairwise comparisons were adjusted for multiple testing using the Bonferroni method.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE F2

Percentage distributions by demographic characteristics at the student and school levels

Characteristic	Student-level data: Grade 5 (*n* = 51,510)	Student-level data: Grade 8 (*n* = 52,421)	School-level data: Grade 5 (*n* = 786)	School-level data: Grade 8 (*n* = 469)
Female students	49.1	49.4	48.6	48.4
Students eligible for free or reduced-price lunch	34.6	31.1	43.7	40.1
Limited English proficient students	3.9	3.0	10.2	5.7
Students identified for special education services	13.3	10.9	14.3	15.2
White students	78.6	80.1	71.6	78.0

Note: Percentages might not sum to totals because of rounding. For each grade, *n* is either the number of students or the number of schools. The differences in the percentages between the student-level and school-level data could be due to the differences in students included in each set of calculations. The student-level data included only students from grades 5 and 8 who were included in the analyses; the school-level data included students from all grades in schools that contain either grade 5 or grade 8.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE F3

Number of limited English proficient students removed from the analyses based on missing student or school characteristics for grade 5

Characteristic	Limited English proficient students with missing data: Number	Limited English proficient students with missing data: Percentage of original sample with missing data
Original sample	4,991	na
Student characteristics		
Minnesota Comprehensive Assessment–Series II (MCA–II) science scores	96	1.9
Student demographics (gender, eligibility for free or reduced-price lunch, special education status, limited English proficiency status, race/ethnicity)	0	0.0
Prior-year student achievement on MCA–II math	2,837	56.8
Prior-year student achievement on MCA–II reading	601	12.0
School characteristics		
Student-related (percentage of female students, students eligible for free or reduced-price lunch, students identified for special education services, limited English proficient students, White students)	175	3.5
Teacher-related (years of teaching experience, teacher degree attainment, student–teacher ratio)	10	0.2
School average prior-year academic achievement	181	3.6
Students with deleted data	2,966[a]	59.4[b]
Final analytic sample for research questions 1 and 3	2025	40.6

na is not applicable.

Note: Percentages might not sum to total because of rounding.

a. This number does not equal the sum of the missing school and student characteristics because some students were missing more than one characteristic.

b. This percentage does not equal the sum of the missing school and student characteristics because some students were missing more than one characteristic.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE F4

Differences between the analytic sample of limited English proficient students used in the analyses and excluded students, based on Minnesota Comprehensive Assessment–Series II scores and other demographic characteristics for grade 5

	Analytic sample of limited English proficient students			Limited English proficient students excluded from the analytic sample			
Characteristic	*n*	Mean	Frequency (percent)	*n*	Mean	Frequency (percent)	*p*-value
Achievement on Minnesota Comprehensive Assessment–Series II (MCA–II) science	2,025	534.49	na	2,870	531.21	na	< 0.001
Female	2,025	na	46.5	2,966	na	48.1	0.26
Eligible for free or reduced-price lunch	2,025	na	87.6	2,966	na	86.6	0.32
Identified for special education services	2,025	na	13.0	2,966	na	16.4	< 0.001
Non-White race/ethnicity	2,025	na	3. 5	2,966	na	5.9	< 0.001
Prior-year achievement MCA–II math	2,025	447.11	na	129	440.76	na	< 0.001
Prior-year achievement MCA–II reading	2,025	444.08	na	2,365	440.67	na	< 0.001

na is not applicable.

Note: T-tests were conducted to examine differences between the analytic limited English proficient sample and excluded limited English proficient sample for MCA–II science, MCA–II prior-year reading achievement, and MCA–II prior-year math achievement. Chi-square tests were conducted to examine differences between the analytic limited English proficient sample and the excluded limited English proficient sample based on gender (male/female), free or reduced-price lunch (eligible/not eligible), special education status (identified/not identified), and race/ethnicity (White/non-White).

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE F5

Number of limited English proficient students removed from the analyses based on missing student or school characteristics for grade 8

Characteristic	Limited English proficient students with missing data: Number	Limited English proficient students with missing data: Percentage of original sample with missing data
Original sample	3,502	na
Student characteristics		
Minnesota Comprehensive Assessment–Series II (MCA–II) science scores	65	1.9
Student demographics (gender, eligibility for free or reduced-price lunch, special education status, limited English proficiency status, race/ethnicity)	0	0.0
Prior-year student achievement on MCA–II math	1,728	49.3
Prior-year student achievement on MCA–II reading	453	12.9
School characteristics		
Student-related (percentage of female students, students eligible for free or reduced-price lunch, students identified for special education services, limited English proficient students, White students)	8	0.2
Teacher-related (years of teaching experience, teacher degree attainment, student–teacher ratio)	29	0.8
Students with deleted data	1,925[a]	55.0[b]
Analytic sample for research questions 1 and 3	1,577	45.0
School average prior-year academic achievement	272	7.8

na is not applicable.

Note: Percentages might not sum to total because of rounding.

a. This number does not equal the sum of the missing school and student characteristics because some students were missing more than one characteristic.

b. This percentage does not equal the sum of the missing school and student characteristics because some students were missing more than one characteristic.

Source: Authors' analysis based on data from the Minnesota Department of Education.

TABLE F6

Differences between the analytic sample of limited English proficient students used in the analyses and excluded students, based on Minnesota Comprehensive Assessment–Series II scores and other demographic characteristics for grade 8

	Analytic sample of limited English proficient students			Limited English proficient students excluded from the analytic sample			
Characteristic	*n*	Mean	Frequency (percent)	*n*	Mean	Frequency (percent)	*p*-value
Achievement on Minnesota Comprehensive Assessment–Series II (MCA–II) science	1,577	837.68	na	1,860	833.20	na	< 0.001
Female	1,577	na	45.5	1,925	na	46.1	0.72
Eligible for free or reduced-price lunch	1,577	na	88.7	1,925	na	88.2	0.66
Identified for special education services	1,577	na	13.1	1,925	na	14.4	0.28
Non-White race/ethnicity	1,577	na	2.9	1,925	na	7.3	< 0.001
Prior-year achievement MCA–II math	1,577	738.65	na	197	725.05	na	< 0.001
Prior-year achievement MCA–II reading	1,577	737.44	na	1,472	733.41	na	0.006

na is not applicable.

Note: T-tests were conducted to examine differences between the analytic limited English proficient sample and excluded limited English proficient sample for MCA–II science, MCA–II prior-year reading achievement, and MCA–II prior-year math achievement. Chi-square tests were conducted to examine differences between the analytic limited English proficient sample and the excluded limited English proficient sample based on gender (male/female), free or reduced-price lunch (eligible/not eligible), special education status (identified/not identified), and race/ethnicity (White/non-White); $p = 0.28$.

Source: Authors' analysis based on data from the Minnesota Department of Education.

NOTES

1. Full-time equivalent credits represent the amount of time per week a teacher is reported in a teaching assignment.

2. For a review, see Hanushek (1999).

3. Although the analyses for both of the first two research questions look at the relationship between gender and achievement, for instance, the relationships addressed differ. As Snidjers and Bosker (1999, p. 13–16) point out, these two relationships have different meanings and the relationship between individual characteristics and individual outcomes can be in the opposite direction (as is the case here for gender) of the relationship between aggregated characteristics and aggregated outcomes.

4. Hanushek (1999) found that lower performance can be associated with smaller class sizes, but there are many factors that might affect class size and performance. For example, schools with many struggling or disadvantaged students might reduce class size to accommodate these students and improve their achievement. These schools might have performed even worse if their average classroom size was larger.

5. The within-school variance for Model 1 is not shown in table E1 because the focus of this section is on differences between schools.

6. Results for limited English proficiency are not reported because more than half of limited English proficient students had missing data and were removed from the sample. Those that remained were not representative of all limited English proficient students, which could bias results for a comparison of limited English proficient and non–limited English proficient students.

7. See "standardized mean differences" in box 2 for information on the magnitude of effect sizes.

8. Random error includes unpredictable events or circumstances that can affect how students perform on a test. Random error can come from differences in how schools administer the test or in how students react to the test based on such factors as their mood, the time of day, and so on.

9. The percentage of students with limited English proficiency had a statistically significant correlation. However, because of the large amount of missing data (see box 3), results for limited English proficient students could be misleading and are thus not discussed.

10. This item applies to the special education students who took the MCA–II.

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