Northwestern | Center for Education Efficacy, Excellence, and Equity (E4)
SCHOOL OF EDUCATION AND SOCIAL POLICY

Student Performance in Math Domains

Across School Settings Grades 1-5

Amy Auletto and the E4 Team

May 2023

About E4

To improve K-12 education and address educational inequities, school districts need timely, rigorous analyses of student outcome data. Housed within Northwestern University's School of Education and Social Policy, the Center for Education Efficacy, Excellence, and Equity (E4) is a research-practice partnership that brings together Northwestern researchers, school districts, and the technology company Curriculum Associates to produce usable knowledge for educational practitioners. The E4 Center is generously supported by The Bill & Melinda Gates Foundation.

Paul Goren
Director

Amy Auletto
Assistant Director

Ofer Malamud
SESP Faculty Advisor

Lex Winter
Communications Specialist

Davis Caron-Vera
Program Coordinator

Asia Ellis
Data Coordinator

Alonzo Lepper
Data Coordinator

Sarah Collier
Post-Doctoral Fellow

Sebastian Castrechini
Graduate Student Fellow

Sofía Bahena
Early Career Scholar

Camila Morales
Early Career Scholar

e4.northwestern.edu

Cite as:

Auletto, A. (2023). Student Performance in Math Domains Across School Settings: Grades 1-5. Evanston, IL: Center for Education Efficacy, Excellence, and Equity, Northwestern University. https://e4.northwestern.edu/

Contents

01

Introduction

Differences in academic performance across demographic groups are a well-documented and persistent feature of the U.S. education system.[1] School characteristics such as poverty levels and racial/ethnic composition consistently predict performance on achievement tests in all content areas, including math.

Reframing achievement gaps as an issue of unequal learning opportunities, Alfinio Flores identified several factors contributing to disparate trends in math learning, including access to experienced and qualified teachers, exposure to lower expectations, and inequitable funding.[2] Nationally, elementary math teachers are often not well prepared to teach math.[3] This is increasingly problematic in upper elementary grade levels when math concepts become more complex and varied, with an increased emphasis on algebraic thinking.[4] Existing between-school differences in math learning grew after the onset of the COVID-19 pandemic, which brought disruptions to in-person learning and other educational opportunities.[5]

While we know there are differences in math learning across school settings, we know less about how performance varies across specific learning domains within math, such as algebra and geometry. In this research brief, we provide a nuanced description of this phenomenon through the analysis of math assessment data from a national sample of elementary students.

Our work is guided by the following research question:

How does math domain learning vary by school-level demographics, across grade levels, and over time?

By identifying and describing variation in math learning across domains, we provide insights for both researchers and practitioners on how to most effectively focus instruction and interventions to address differences in math learning across school settings. The two dimensions of school setting we examine are poverty level and racial/ethnic composition; in our study the term "setting" refers only to these school-level demographic characteristics.

1. See, for example, Lucas et al. (2018); Reardon (2011)
2. Flores (2007)
3. Center for Research in Mathematics and Science Education (2010)
4. Demonty et al. (2018)
5. Goldhaber et al. (2022)

In this research brief, we report on the extent to which more than four million students in grades 1-5 met grade level expectations in math from 2019 to 2022 on i-Ready's diagnostic assessment, a diagnostic computer-adaptive test used across the country.

We compare outcomes in four math domains:

Algebra and Algebraic Thinking	Geometry	Measurement and Data	Numbers and Operations
Number patterns, conceptual understanding of operations, use of symbols, equations	Skills needed to analyze two- and three-dimensional shapes	Collecting, organizing, and interpreting numerical information	Reading, writing, and basic operations with all settings of numbers

We classify and compare school setting by poverty status and racial/ethnic composition using the following definitions:

Poverty		Race/ethnicity	
High %FRL	Low %FRL	High %SoC	Low %SoC
Schools where 90-100% of students are eligible for free or reduced-price lunch (FRL), a proxy measure for students living in poverty	Schools where 0-85% of students are eligible for free or reduced-price lunch	Schools with populations that are 90-100% students of color	Schools with populations that are 0-85% students of color

For more on our analytic sample and approach, please see the technical appendix.

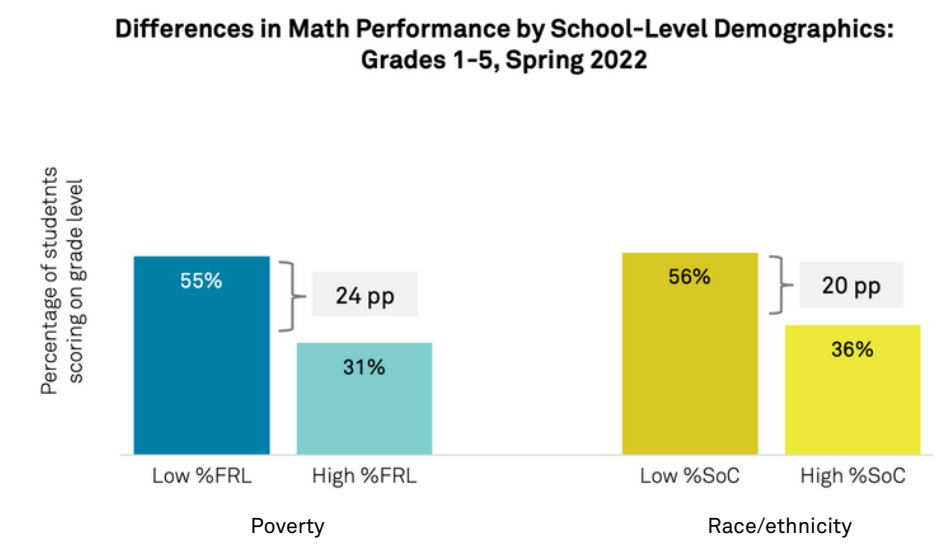
In the remainder of this research brief, we describe variation in math performance by school setting and math domain (Section 2), math performance as students advance through elementary school (Section 3), and longitudinal trends in math performance by domain (Section 4). After presenting these findings, we take a closer look at student learning in algebra (Section 5) and conclude with a discussion of implications (Section 6).

02 Variation by School Setting & Domain

In alignment with well-established patterns in math performance by school setting, spring 2022 i-Ready diagnostic math scores reveal substantial differences in achievement based on school poverty status and racial/ethnic composition.

Elementary students attending schools with a higher proportion of free and reduced-price lunch recipients were far less likely to meet grade level expectations in math than their peers who attended schools with a lower proportion of free and reduced-price lunch recipients (31% vs. 55%). Similarly, elementary students who attended schools with a higher proportion of students of color were less likely to score on grade level in math than their peers in schools with more white students (36% vs. 56%).

School Setting

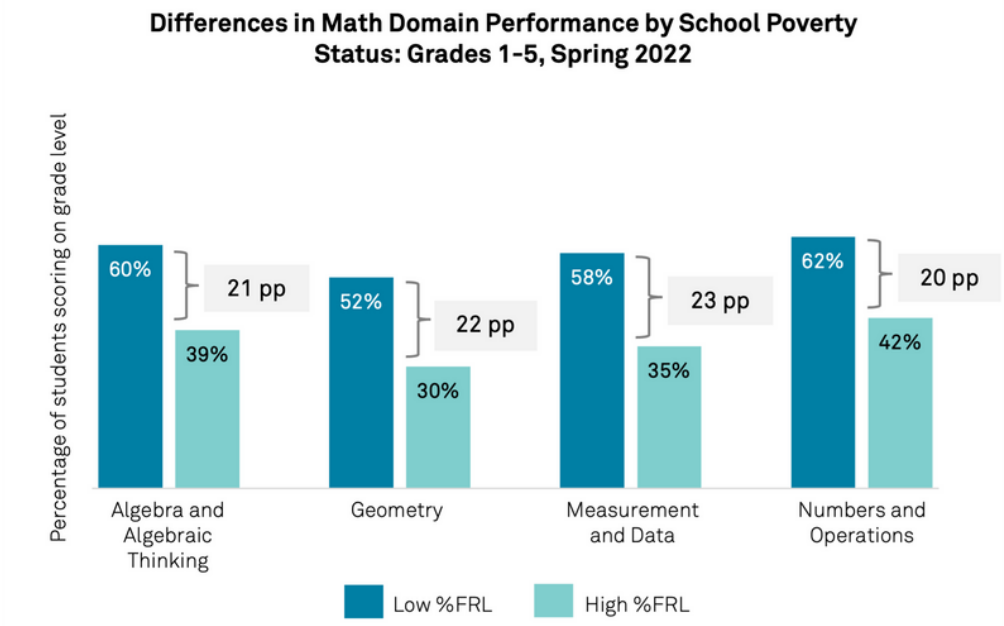


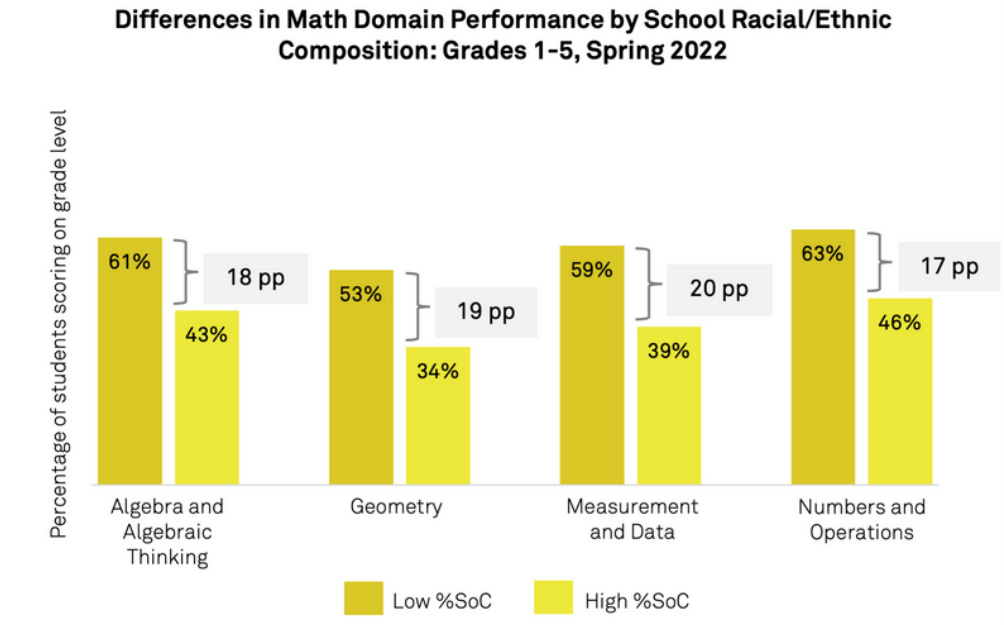
To better understand how practitioners, policymakers, and other education stakeholders can most effectively address these school-level differences in math performance, we turn next to comparisons across math domains.

Differences in math domain performance varied based on both school poverty status and racial/ethnic composition. Differences by school poverty status ranged from 20 to 23

percentage points. Differences based on school racial/ethnic composition ranged from 17 to 20 percentage points. Across all school settings (low %FRL, high %FRL, low %SoC, high %SoC), Geometry was the most challenging domain and Numbers and Operations was a bright spot.

Domains





03 Math Performance by Grade

Continuing with our examination of 2022 i-Ready math diagnostic scores, we compared math performance by school setting among two subsets of students—first-grade students and fifth-grade students—with the goal of determining whether performance differences tended to increase or decrease as students advanced through the elementary grades. Our findings were mixed; differences in overall math performance were slightly greater among fifth graders than first graders based on school poverty status, while differences based on school racial/ethnic composition were slightly smaller among fifth graders than they were among first graders.

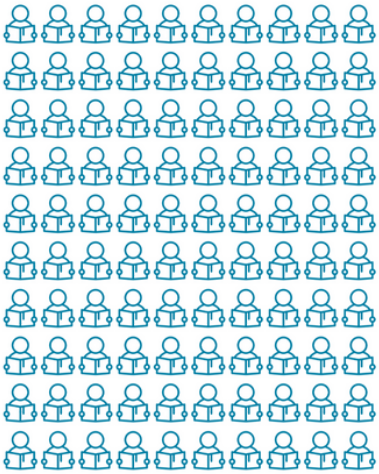
i-Ready Fast Facts

- i-Ready is a suite of products made by the educational technology company Curriculum Associates
- Tests are computer-delivered diagnostic assessments administered at three points throughout the school year
- Used by ~11 million students at 38,000+ schools
- Unlike high-stakes assessments such as state standardized tests, i-Ready assessments are meant to serve as an iterative measure of student progress that school leaders and teachers can use to inform practice

As students advance through elementary school, differences in overall math performance based on school poverty levels appear to increase slightly.

Poverty

For every 100 first-graders in low %FRL schools who score on grade level in math...



...only 58 first-graders in high %FRL schools did so.

Among fifth graders, this proportion is 56 students for every 100.

Race/Ethnicity

For every 100 first-graders in low %SoC schools who score on grade level in math...

...only 63 first-graders in high %SoC schools did so.

Among fifth graders, this proportion is 65 students for every 100.

To further contextualize these findings, we compared math domain performance for first- and fifth-grade students by school-level demographics. First looking at differences based on school poverty status, we found that in nearly all instances, differences in math performance widen as students advance through elementary school. Most notably, while first-grade students had a 72 percent chance of being on grade level in Algebra and Algebraic Thinking relative to their peers in low %FRL schools, this drops to 59 percent among fifth-grade students.

Results based on school racial/ethnic composition were mixed. Fifth-grade students in high %SoC schools were less likely than their same-school first-grade peers to perform on grade level in Algebra and Algebraic Thinking and Numbers and Operations, while differences in performance in Geometry and Measurement and Data remained constant or decreased.

Poverty
Likelihood of Students in High %FRL Schools Scoring on Grade Level Relative to Same-Grade Peers in Low %FRL Schools, Spring 2022

Domain	Average First Grader	Average Fifth Grader	Suggested Trend
Algebra and Algebraic Thinking	72%	59%	Increasing
Geometry	61%	56%	Increasing
Measurement and Data	60%	60%	Consistent
Numbers and Operations	69%	61%	Increasing

Race/Ethnicity
Likelihood of Students in High %SoC Schools Scoring on Grade Level Relative to Same-Grade Peers in Low %SoC Schools, Spring 2022

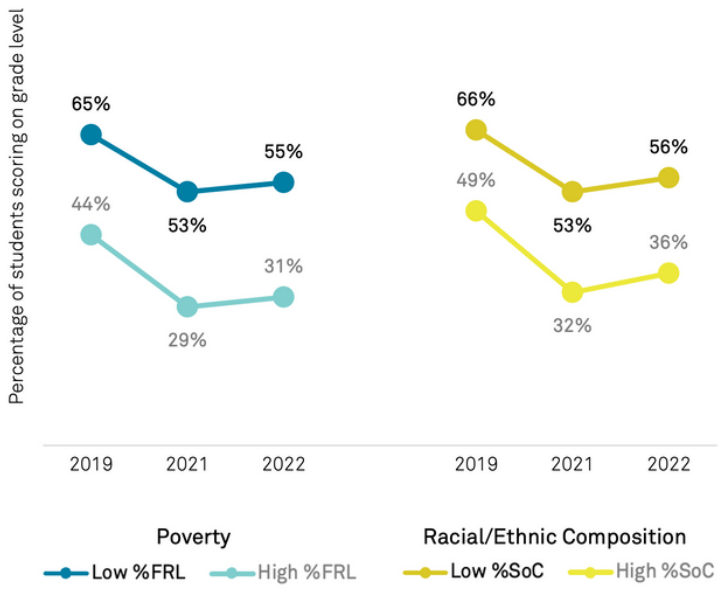
Domain	Average First Grader	Average Fifth Grader	Suggested Trend
Algebra and Algebraic Thinking	75%	67%	Increasing
Geometry	65%	65%	Consistent
Measurement and Data	61%	69%	Decreasing
Numbers and Operations	73%	69%	Increasing

04 Performance Trends Over Time in Math Domains

On-grade-level math performance has dropped substantially since the onset of the COVID-19 pandemic. Across all school settings considered in this analysis, the proportion of elementary students who met grade-level expectations in math dropped anywhere from 12 percentage points (low %FRL schools) to 17 percentage points (high %SoC schools) immediately following the start of the COVID-19 pandemic. In all cases, there is evidence of a slight rebound in 2022.

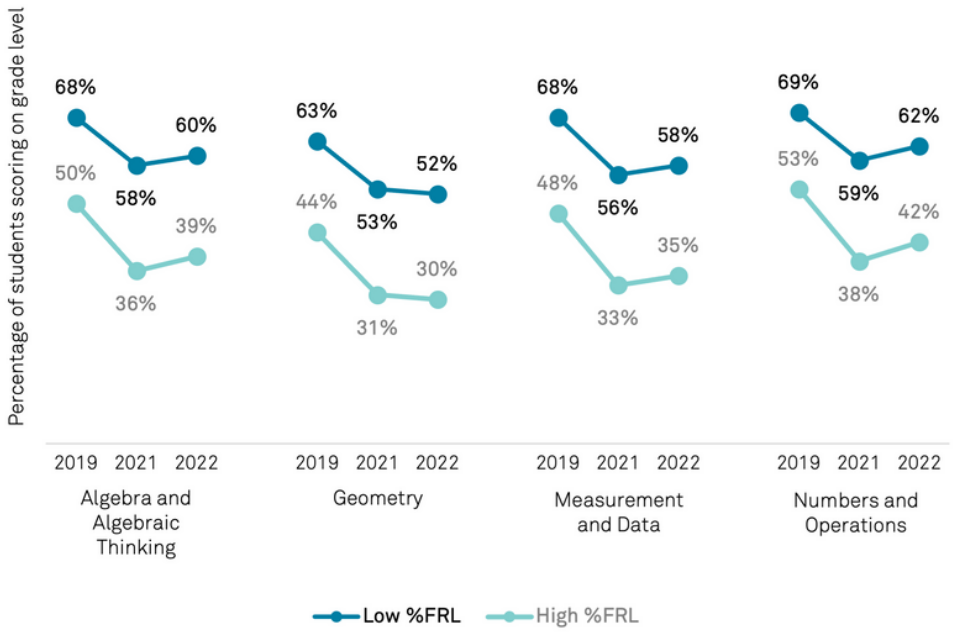
Despite this rebound, differences in performance by school setting in 2022 were greater than in 2019. Comparing high %FRL and low %FRL schools, differences grew by three percentage points. For high %SoC and low %SoC schools, differences also grew by three percentage points.

Longitudinal Trends in Math Performance by School Setting: Grades 1-5, Spring '19 - Spring '22



To further contextualize these findings, we examined longitudinal trends in math performance by domain and school setting. Comparing high %FRL and low %FRL schools, we found that performance in all math domains dropped substantially immediately following the pandemic, with evidence of a slight rebound in all domains except for Geometry. As with overall math performance trends, differences by school settings were larger in 2022 than they were prior to the pandemic.

Longitudinal Trends in Math Domain Performance by School Poverty Status: Grades 1-5, 2019-2022



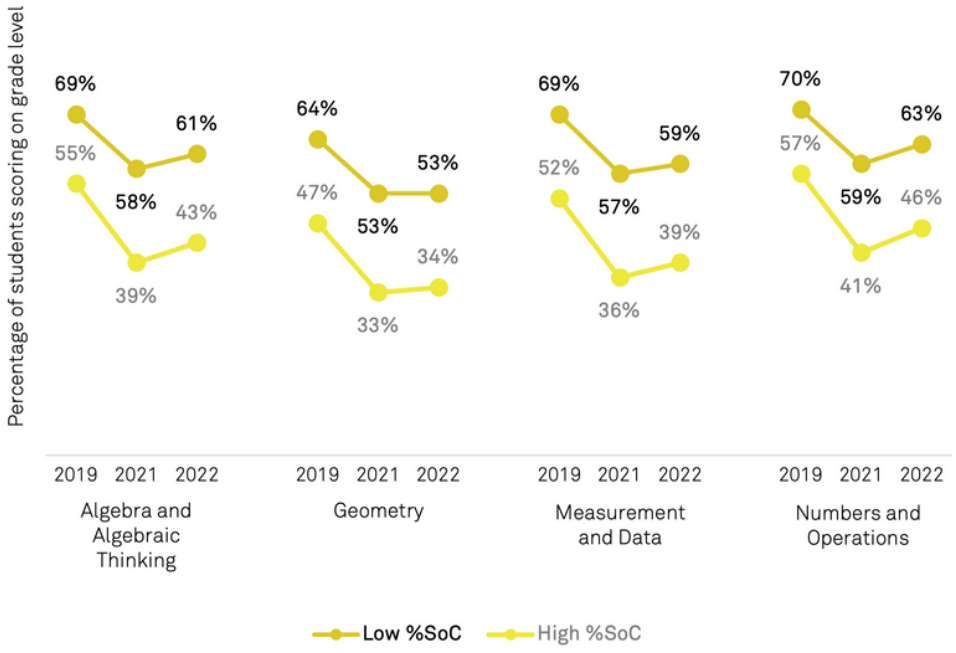
As the figure above shows, from 2019 to 2022 the differences between proportions of students scoring on grade level grew:

- In Algebra and Algebraic Thinking, from 18 to 21 percentage points
- In Geometry, from 19 to 22 percentage points
- In Measurement and Data, from 20 to 23 percentage points
- In Numbers and Operations, from 16 to 20 percentage points

(Due to pandemic-related disruptions, no data were available for 2020.)

Comparing high %SoC and low %SoC schools (see figure on following page), we found that performance in all math domains dropped substantially immediately following the pandemic, with evidence of a slight rebound in all domains in 2022. Despite this slight rebound, percentage-point differences remained larger in 2022 than they were prior to the pandemic.

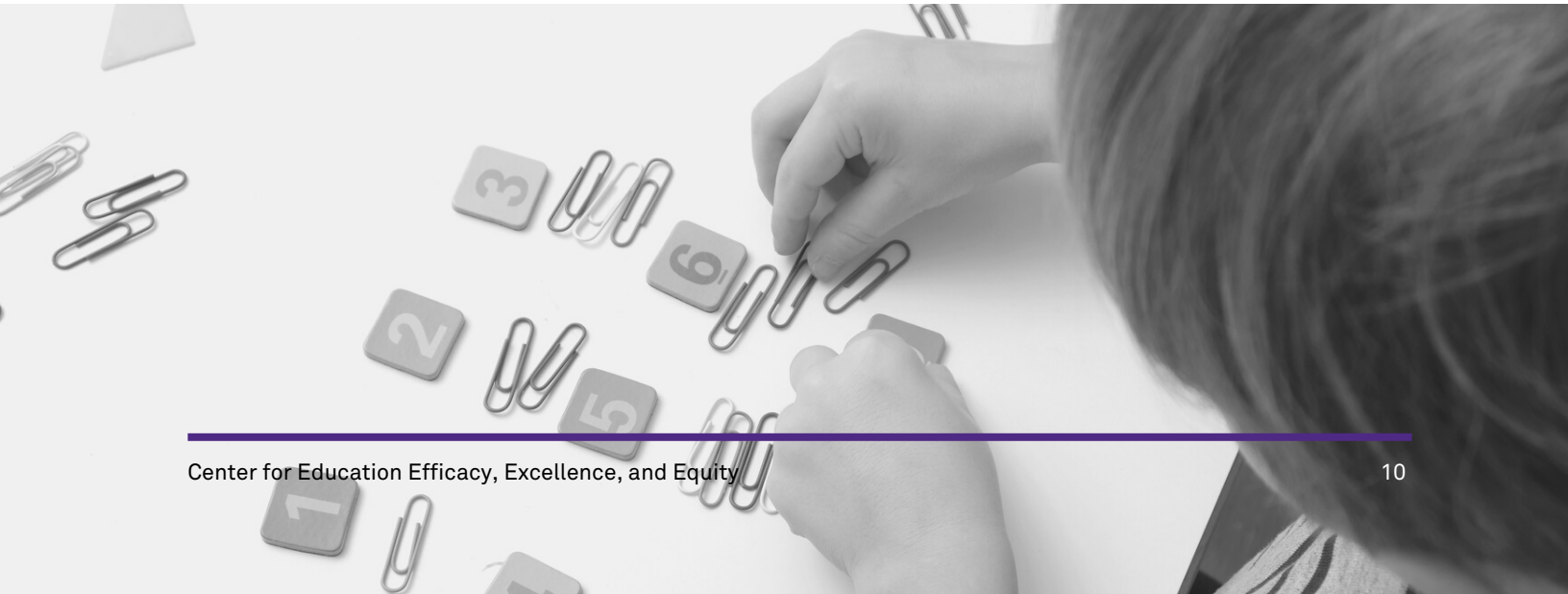
Longitudinal Trends in Math Domain Performance by School Racial/Ethnic Composition: Grades 1-5, 2019-2022



As the figure above shows, from 2019 to 2022 the differences between proportions of students scoring on grade level grew:

- In Algebra and Algebraic Thinking, from 14 to 18 percentage points
- In Geometry, from 17 to 19 percentage points
- In Measurement and Data, from 17 to 20 percentage points
- In Numbers and Operations, from 13 to 17 percentage points

(Due to pandemic-related disruptions, no data were available for 2020.)



05 A Closer Look at Algebra

For decades, researchers and educators alike have argued that algebra plays a critical role in students' academic trajectories and later career prospects.[6] The importance of algebra coupled with findings from our analysis of i-Ready math diagnostic scores make it clear we need to delve further into this specific component of math learning.

We found that differences in on-grade-level performance in Algebra and Algebraic Thinking increase as students advance through the elementary grades. While first-grade students in high %FRL schools were 72 percent as likely to meet grade level expectations in math as their same-grade peers in low %FRL schools, this was only true for 59 percent of fifth-grade students when making the same comparison. Similar declines were found based on school racial/ethnic composition. Furthermore, differences in on grade level performance in Algebra and Algebraic Thinking were greater following the beginning of the pandemic. Despite a slight rebound, differences in the proportions of students scoring on grade level in this domain remained at 21 and 18 percentage points based on school poverty status and school racial/ethnic composition, respectively, in 2022.

In response to these findings, we sought to identify the algebra skills that students were most likely to struggle with so that we could generate actionable recommendations about how to best support students and reduce differences in outcomes based on school setting.

To this end, we examined a subset of students who also completed algebra lessons using i-Ready's personalized learning platform in the 2021-22 school year to determine which lessons and associated skills with which students were most likely to struggle.[7] We identified the 20 algebra lessons that students in grades 1-5 were least likely to master and reviewed the 15 associated Common Core State Standards (CCSS) that these lessons supported. Summarized in the table that follows, we found that numerous standards related to word problems (6 of 15) while another 5 standards addressed other more complex critical thinking skills, requiring that students interpret and explain, for example.

These findings suggest that instructional interventions focused on understanding word problems and thinking critically may be particularly effective in addressing differences in algebra performance by school setting to prepare students for greater success as they advance through elementary school and beyond.

6. See, for example, Usiskin (1995); Vogel (2008)
7. See technical appendix for more details on this subset and analysis.

Common Core State Standards Related to Algebra That Challenged Elementary Students in 2021-2022

Standard	Brief Description
K.OA.A.3	Decompose numbers less than or equal to 10 into pairs in more than one way.
1.OA.A.1	Use addition and subtraction within 20 to solve word problems.
1.OA.B.4	Understand subtraction as an unknown-addend problem.
1.OA.C.5	Relate counting to addition and subtraction (e.g., by counting on 2 to add 2).
2.OA.A.1	Use addition and subtraction within 100 to solve one- and two-step word problems.
2.OA.C.3	Determine whether a group of objects (up to 20) has an odd or even number of members.
2.OA.C.4	Use addition to find the total number of objects arranged in rectangular arrays.
3.OA.A.1	Interpret products of whole numbers.
3.OA.A.2	Interpret whole-number quotients of whole numbers.
3.OA.A.3	Use multiplication and division within 100 to solve word problems.
3.OA.D.8	Solve two-step word problems using the four operations.
3.OA.D.9	Identify arithmetic patterns and explain them using properties of operations.
4.OA.A.1	Represent verbal statements of multiplicative comparisons as multiplication equations.
4.OA.A.2	Multiply or divide to solve word problems involving multiplicative comparison.
4.OA.A.3	Solve multistep word problems posed with whole numbers using the four operations

Source : https ://learning.ccsso.org/common-core-state-standards-initiative

06

Conclusion

These findings shed light on widespread differences in math domain learning across school settings, grade levels, and time. Fortunately, there are steps that researchers and practitioners can take to help address these differences.

Elementary students who attended schools with higher poverty levels and schools with higher proportions of students of color were less likely to score on grade level across all math domains. Although differences in math performance widened immediately following the start of the COVID-19 pandemic, there is some evidence that differences are beginning to return to pre-pandemic levels. However, these differences are still substantial.

We found that differences by school setting within the Algebra and Algebraic Thinking domain were particularly large, with evidence that specific skills in this domain may be contributing to students' below-grade level performance. Math tasks involving word problems and critical thinking, for example, were particularly challenging for students. Based on this information, educators might consider devoting additional instructional time to these areas. Additionally, district leaders might explore opportunities to direct resources toward targeted strategies and initiatives, such as high-dosage tutoring.

Although we focused specifically on challenges within the Algebra and Algebraic Thinking domain in this research brief, we acknowledge that substantial differences in math learning are present across all domains. Our future work will continue to explore struggle points and bright spots within other math domains and consider the role of foundational reading skills in supporting math learning. By more clearly identifying the mathematical skills that students find challenging, we can more effectively address the broad inequities that exist across schools.

Let us know

How do you interpret these findings?

What questions do you have?

What interventions do you believe are most urgently needed to address uneven student performance in math?

Get in touch at e4center@northwestern.edu and on Twitter at @E4Center_NU.

References

Center for Research in Mathematics and Science Education. (2010). Breaking the Cycle: An International Comparison of U.S. Mathematics Teacher Preparation. East Lansing: Michigan State University.

Demonty, I., Vlassis, J., & Fagnant, A. (2018). Algebraic thinking, pattern activities and knowledge for teaching at the transition between primary and secondary school. Educational Studies in Mathematics, 99, 1–19.

Flores, A. (2007). Examining Disparities in Mathematics Education: Achievement Gap or Opportunity Gap? The High School Journal 91(1), 29-42.

Goldhaber, D. Kane, T. J., McEachin, A., Morton, E., Patterson, T., & Staiger, D. O., (2022).The consequences of remote and hybrid instruction during the pandemic. NBER Working Paper 30010. Retrieved from https://www.nber.org/papers/w30010

Lucas, S. R. & Irwin, V. (2018). Race, class, and theories of inequality in the sociology of education. In B. Schneider (Ed.), Handbook of sociology of education in the 21st century (pp. 73-107).

Reardon, S. F. (2011). The widening academic achievement gap between the rich and the poor: New evidence and possible explanations. In G. J Duncan & R. J. Murnane (Eds.), Whither opportunity? Rising inequality, schools, and children's life chances (pp. 91-116).

Usiskin, Z. (1995). Why is algebra important to learn? American Educator, 19(1), 30-37.

Vogel, C. (2008). Algebra: Changing the equation. District Administration, 44(6), 34-38.