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Policy Brief

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Missing the Mark: Students Gain Little from Mandating Extra Math and Science Courses

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Evidence suggests that changing course requirements alone may not be enough to prepare students for college and career.

Introduction

For several decades, policymakers have embraced the goal of preparing students for college and careers, particularly for careers in the area of mathematics and science. The recent emphasis on these STEM (science, technology, engineering, and mathematics) subjects is due to the growth of STEM occupations and the perceived shortage of qualified workers to fill these positions.[1] There is a concern that many students do not currently have the level of STEM capabilities necessary for high-skill STEM professions such as engineering or even for low-skill STEM positions in fields such as manufacturing.[2]

To better prepare students for these STEM careers, many states have increased the mandated minimum course requirements in math and science over the past several years. Twenty-seven states required at least one more year of math instruction for the high school graduation class of 2013 than for the class of 2006.[3] Similarly, 19 states required an additional year of science for 2013 high school graduates compared to 2006 graduates. In 2013, 42 states required students to take at least three years of math, and 37 states required at least three years of science. These policies aim to expose more students to sophisticated math and science concepts, and the extra rigor is intended to improve student outcomes in college or the workforce. Although these state minimum requirements are binding on all students, in practice they only affect a minority of students since most college-bound students have traditionally exceeded these minimums, and some districts had similar requirements in place already.[4]

Using student-level data for nine Illinois high school graduation classes, this report examines the relationship between high school graduation requirements and student outcomes and assesses how changes in math and science requirements affected student outcomes. In August 2005, Illinois enacted Public Act 94-0676 aimed at increasing the rigor of high school by mandating more stringent high school graduation requirements. Prior to the reform, most districts allowed high school students to graduate with only two years of math (60%) and fewer (15%) required only one year of science.[5] The law set a state minimum graduation requirement of three years of math—including Algebra I and Geometry content—and two years of science.[6] The law was phased in over a four-year period. Each year from 2005 to 2008, entering freshman were responsible for completing more coursework, with the full reform package applicable for the graduating class of 2013. The mandatory state math requirement rose from two years for graduation classes through 2008 to three years for the 2009 graduation class. Two years of science were required by the state for the 2011 graduation compared to a one-year requirement for earlier classes.

This study used ACT,[7] National Student Clearinghouse,[8] and Illinois State Board of Education survey[9] data to examine the effects of the reform for public school students,[10]

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particularly students in the bottom half of their graduating class. We compared trends in course taking, achievement, and college enrollment for districts that were affected by the new statewide requirements (*treated districts*) relative to other districts that already required the mandated levels of math and science coursework prior to the law's enactment (*untreated districts*). The new requirements should expose more students to an advanced curriculum often targeted for college-motivated students. Specifically, the study addresses the following three questions:

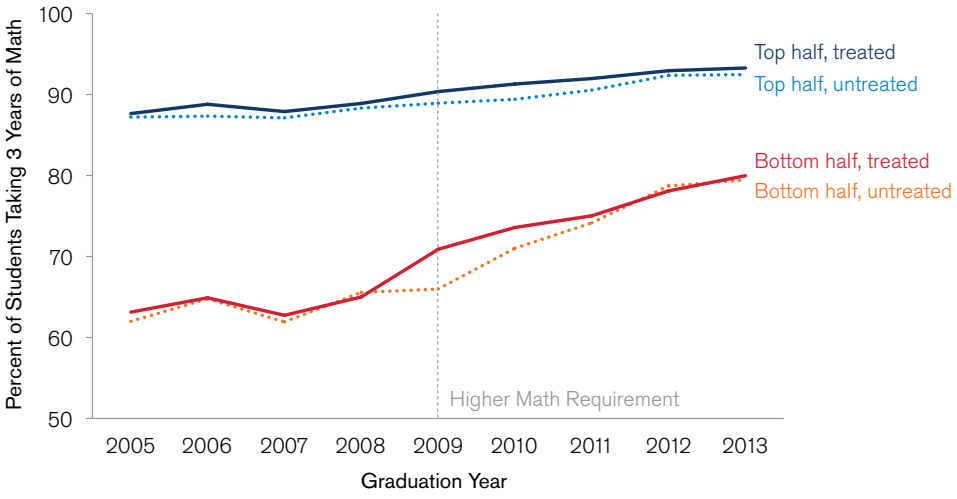
1. Have the new graduation requirements increased math and science course taking?
2. Has student achievement improved in math and science because of the policy change?
3. Have college enrollment trends been affected by the new law?

For each research question, we provide a brief overview and examine the law's effectiveness by comparing trends for treated districts (i.e., those affected by the new law) versus untreated districts (i.e., those that had met or exceeded the requirements of the 2005 statute prior to its enactment). In each case, we compared trends for students in the top and bottom halves of their graduation classes. *A priori*, we expected that the law would have a larger effect on lower-performing students since these students typically took fewer math and science courses. If the law was effective at improving student outcomes, then we should observe that course taking, achievement, and college enrollments would improve at a faster pace in the treated than in the untreated districts.

Course Taking

Interest in student course taking dates back thirty years with the publication of *A Nation at Risk*, which recommended that students graduating from high school should take four years of English language arts; three years each of mathematics, science, and social studies; and a half-year of computer science.[11] A number of states increased their graduation requirements in response to *A Nation at Risk*, but few did so to the report's recommended minimums.[12]

Figure 1. Trends in math course taking by district type, class rank, and high school graduation year, 2005–2013



Past research examining the relationship between graduation requirements and course taking has found that graduation requirements affect only a few students because most students would have taken the courses regardless of the requirements.[13] For those few students who would not voluntarily take the courses, some studies found an increase in coursework associated with graduation requirements for certain subgroups of students such as low-achieving students.[14]

Math

In Illinois the math requirement was raised to three years of math courses. Consistent with prior research, about 90% of the high-achieving graduates were already taking three or more years of math prior to the graduation requirement reform (Figure 1). This was the same whether the student was in a treated or untreated district. Interestingly, neither the treated nor untreated districts reached 100% compliance with the requirements. It is possible that the requirements are not enforced in practice or are satisfied with credits for repeating courses or for foundational or business math courses.

Approximately two-thirds of low-ranking students in both the treated and untreated districts were taking at least three years of math in 2005. By 2013, math course taking increased to nearly 80% for the low-ranking students. The increase in course taking is encouraging; however, the increase in course taking occurred whether students were in the treated or untreated districts. Although more students were taking at least three more pure math courses than before, the trend in districts affected by the higher math graduation requirement differed little, if at all, from the trend in unaffected districts. It

is possible that the enactment of the state law encouraged the untreated districts to enforce their preexisting policy, particularly with low-ranking students, but we are unable to attribute the rise in math course taking directly to the law.

Science

The law had little effect on science course taking for high-ranking students, but it did seem to improve course taking for low-ranking students. In the treated districts, 78% of low-ranking students took two years of science in 2005 as compared with 88% in 2013. This 10-percentage-point increase compares favorably to a 5-percentage-point increase for low-ranking students in the untreated districts (Figure 2). The science results suggest that the new law is closing a portion of the science-course-taking gap between untreated and treated districts for low-ranked students.

Achievement

Lawmakers hope that exposure to more advanced coursework in math and science will result in higher student achievement. Generally, students who complete core coursework have much higher achievement scores than other students.[15] However, students completing a core coursework voluntarily as preparation for college are likely different from students who are mandated to take the courses. The mandated students may be less motivated or prepared for advanced coursework and may not perform as well as students enrolled in those courses on a voluntary basis.

Math

Math achievement was unaffected by the law. Mathematics Test scores on the ACT® college readiness assessment did rise by small fractions of a point for all four groups from 2005 to 2013, but there was not a statistically significant difference in the trends between treated and untreated districts for either high- or low-ranked students (Figure 3). ACT math scores increased by 0.7 points for low-ranking students in untreated districts compared to 0.6 points for low-ranking students in treated districts.

Since the gains were not significantly different in treated and untreated districts, these test score gains may not be tied to the new mandated math course requirements. Instead, the slightly higher scores may reflect the overall increased math course load that was the trend in all districts over this period. The higher scores could also be related to other changes in education policy and practices in the state or unmeasured changes in the student composition over this period.

Figure 2. Trends in science course taking by district type, class rank, and high school graduation year, 2005–2013

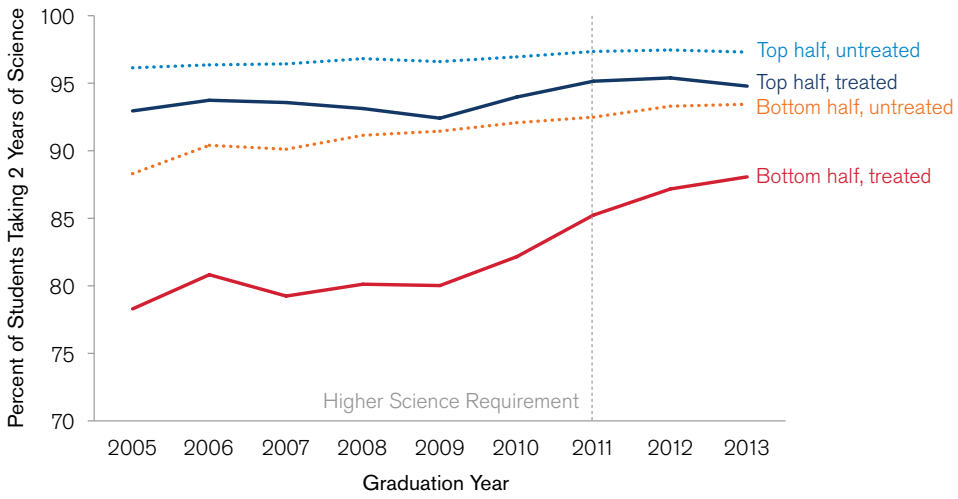
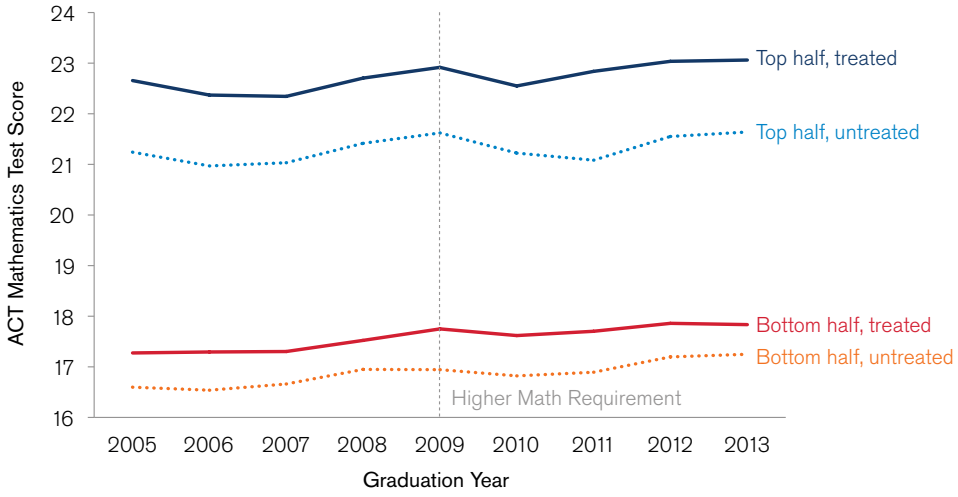


Figure 3. Trends in ACT Mathematics Test scores by district type, class rank, and high school graduation year, 2005–2013



Science

Similar to math, the change in science requirements did not seem to have an effect on science achievement. ACT Science Test scores were comparable across treated

and untreated districts in 2005, and they remained comparable over the period, increasing overall by about 0.7 points (Figure 4). For low-ranking students, the trend was statistically smaller for the treated group than for the untreated group. Science scores still rose for both subgroups in the treated districts, but treated districts' science scores rose at a slower pace than untreated districts'.

This evidence suggests that the two-year science requirement had little effect on science achievement. If effective, the overall trend should have been steeper in districts affected by the requirement. Effective reform should also have especially increased ACT Science Test scores for the low-ranking students who had traditionally taken fewer science courses. Achievement growth was actually lower for low-ranking students in the treated districts than in the untreated districts.

College Enrollment

Research shows that students who voluntarily take more rigorous high school coursework are more likely to enroll and persist in college. Radunzel and Noble, using data from 24,850 ACT-tested high school graduates, found that students who completed a core curriculum were more likely to enroll in college and ultimately be successful in obtaining a college degree.[16] Similarly, Adelman found a relationship between the highest level of high school mathematics completed and bachelor's degree completion.[17] These studies did not take into account whether the course taking was voluntary or mandatory; thus, the findings may not translate to increased college enrollment under the mandated requirement. New requirements effectively target students that may have weaker preparation and motivation for college rather than the group currently choosing more advanced math and science courses.

Figure 4. Trends in ACT Science Test scores by district type, class rank, and high school graduation year, 2005–2013

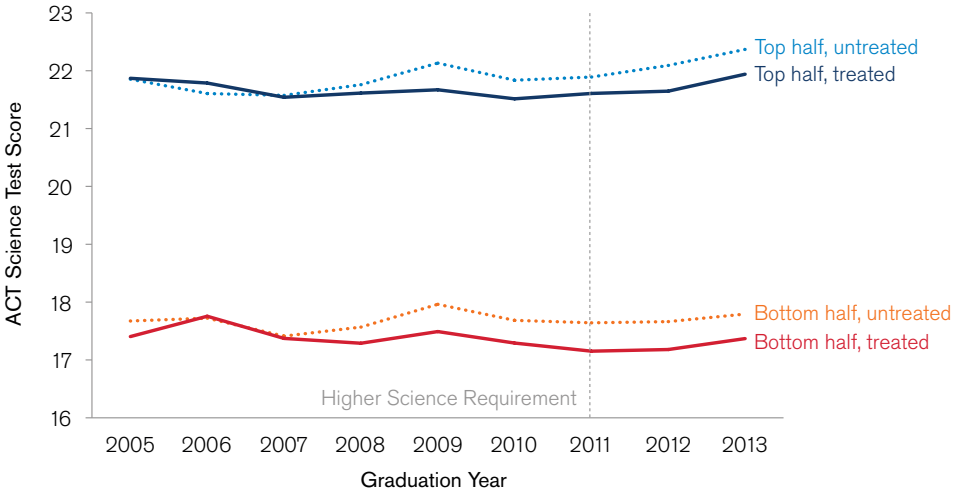
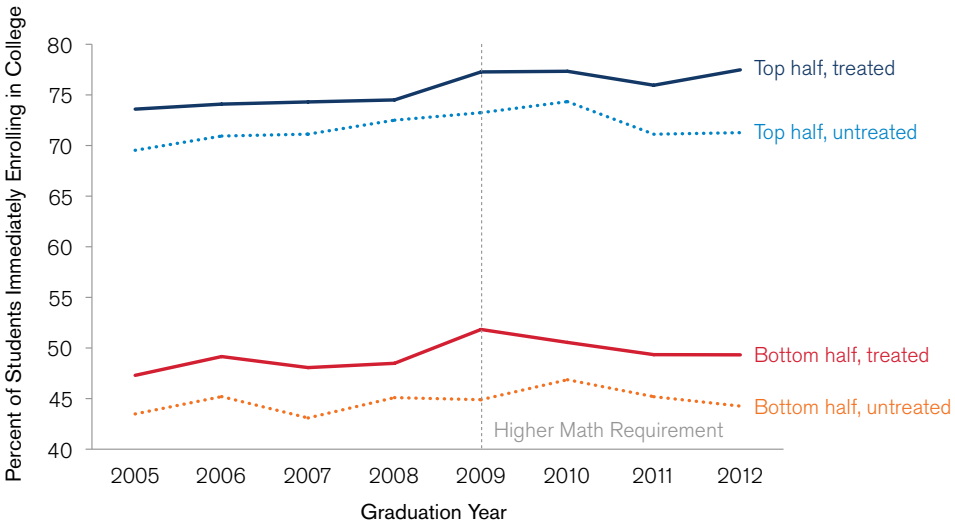


Figure 5. Trends in immediate college enrollment related to math graduation requirements by district type, class rank, and high school graduation year, 2005–2013



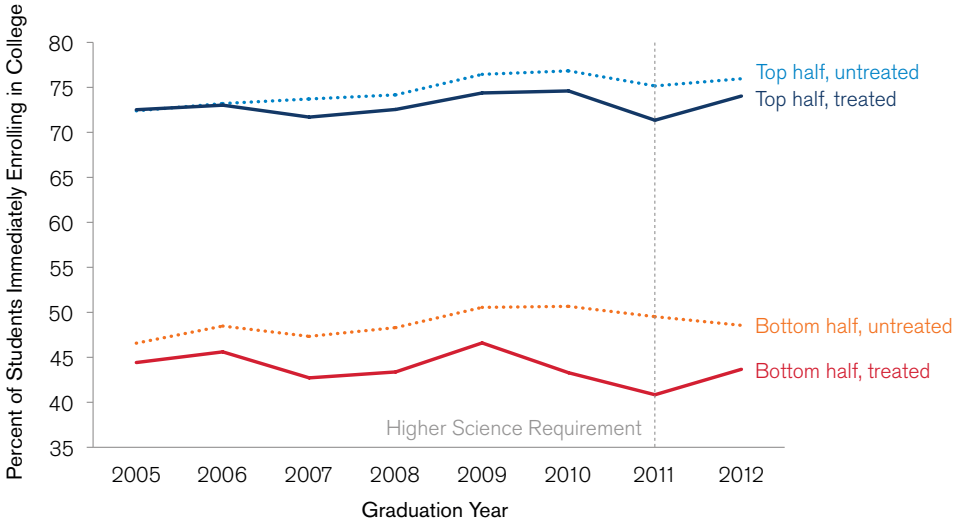
Math

Although math course taking and achievement scores did not appear to be affected by the law, there seemed to be an effect on college enrollment. College enrollment rose faster in districts affected by the higher math requirement than in other districts (Figure 5). Between 2005 and 2012 (2013 enrollment data is not yet available), the enrollment rate for low-ranking students rose 2 percentage points in treated districts (this trend is insignificantly different from zero) and 1 percentage point in the untreated districts. For high-ranking students, the enrollment rate rose 4 percentage points in treated districts and 2 percentage points in untreated districts.

Science

Unlike in math, the science reform had no positive effect on college enrollment (Figure 6). For high-ranking students, college enrollments rose 4 percentage points in treated districts over the eight-year period versus only 2 percentage points in untreated districts. For low-ranking students, enrollment rates rose 2 percentage points in untreated districts and fell 1 percentage point in treated districts. The evidence shows that college enrollments grew at slower rates in districts affected by the higher science requirement than in other districts.

Figure 6. Trends in immediate college enrollment related to science graduation requirements by district type, class rank, and high school graduation year, 2005–2013



Discussion

State policymakers may be unrealistic in expecting that raising math and science graduation requirements alone through state policy will improve student outcomes. Despite the introduction of higher graduation requirements in math and science, there was little effect on student course taking, achievement, or college enrollment. From 2005 to 2013, students took more math courses, but the increase was the same for all students, regardless whether the students were in districts newly subjected to higher graduation requirements or were in districts already requiring the courses. There was also no effect on math achievement scores, but there was an increase in college enrollment. Science course taking did increase more for students in treated than in untreated districts, but this disproportionate increase did not translate into high science achievement scores or an increase in college enrollment.

The research related to high school graduation requirements illustrates that requiring certain courses alone will do little to change student learning and behavior. The shortcoming may reflect that the laws primarily affect lower-ability and less-motivated students who often have weaker preparation for advanced coursework. For students to succeed in these courses, they must possess the necessary prerequisite skills to then take advantage of the advanced material. Efforts should be focused on early preparation to ensure that students have better skills by the time they reach high school. For students already in high school, targeted remediation efforts are necessary, and the remediation efforts may need to be differentiated by ability level, distinguishing students with very weak ability from those only slightly behind.[18]

Another difficulty is ensuring that the courses remain challenging and best prepare students for college and career. An unintended side effect of increasing high school graduation requirements through a mandate is that students may be completing more coursework that is less advanced. As schools expand course offerings, there may be "course credit inflation" which is where "the level of content mastery by the median students receiving credit for a course with a given title declines over time."[19] Thus, as more students are required to take Algebra II, for example, the content covered becomes lessened or easier so as to accommodate the various skill levels of incoming students in the course.

Overall, as states try to increase the preparedness of students for college and career, course requirements alone may not be a sufficient mechanism for change. Exposing students to advanced material is an important first step, but we must recognize that better preparation, better instruction, better student commitment, better parental support, and a host of other factors are needed for students to master these advanced skills. New research is needed to identify what policies and practices will allow a broader cross section of students to embrace and learn advanced concepts. ■

Notes

1 Economics and Statistics Administration, *STEM: Good Jobs Now and for the Future* (Washington, DC: US Department of Commerce, 2011), http://www.esa.doc.gov/sites/default/files/reports/documents/stemfinalyjuly14_1.pdf; National Science Board, *Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Capital* (Alexandria, VA: National Science Foundation, 2010), http://www.nsf.gov/nsb/publications/2010/nsb1033.pdf.

2 National Science Board, *National Action Plan for Addressing the Critical Needs of the U.S. Science, Technology, Engineering, and Mathematics Education System* (Alexandria, VA: National Science Foundation, 2007); Anthony P. Carnevale, Nicole Smith, and Michelle Melton, *STEM* (Washington, DC: Center on Education and the Workforce, Georgetown University, 2011). International assessments of math and science scores are revealing. The United States scores below the international average in mathematics and close to the average in science on the PISA, an international assessment of 15-year-olds. OECD, *Programme for International Student Assessment (PISA) Results from PISA 2012: United States* (Paris, France: OECD, 2013), http://www.oecd.org/unitedstates/PISA-2012-results-US.pdf. Likewise, on the National Assessment of Education Progress (NAEP), only 35% of eighth-graders were proficient or advanced in math in 2013 and only 32% demonstrated proficiency in science in 2011. National Center for Education Statistics, National Assessment of Educational Progress Data Explorer (accessed December 13, 2013), http://nces.ed.gov/nationsreportcard/naepdata/. The PISA and NAEP results are consistent with ACT test-takers. Forty-four percent of ACT-tested 2013 high school graduates met the ACT College Readiness Benchmark in mathematics, and 36% met the science College Readiness Benchmark. ACT, *The Condition of College & Career Readiness 2013* (Iowa City, IA: ACT, 2013).

3 The graduation requirements for the 2006 graduation class were drawn from two studies by Kyle Zinth, *Mathematics Graduation Requirements: Classes 2006 through 2011* (Denver, CO: Education Commission of the States, 2006) and *Science Graduation Requirements: Classes 2006 through 2011* (Denver, CO: Education Commission of the States, 2006). The requirements for the 2013 graduation class are based on author review of state-by-state legislation.

4 Bradford Chaney, Kenneth Burgdorf, and Nadir Atash, "Influencing Achievement through High School Graduation Requirements," *Educational Evaluation and Policy Analysis* 19, no. 3 (1997): 229–244. doi: 10.3102/01623737019003229

5 As mentioned previously, college-bound students would complete more courses than the district minimum.

6 This study focuses on the math and science aspects of the reform. The law also increased the language arts requirement from three to four years along with a two-year writing intensive course requirement that might overlap with other coursework. Students were also required to complete two years of social studies coursework that included United States history or American government as well as an elective.

7 The primary data source for this analysis is high school graduation information collected as part of ACT statewide testing. All public school students in Illinois participate in ACT testing in the spring of their junior year. This includes subtests in English, math, reading, and science. Scores are on a scale from 1 to 36. As part of the test administration, students identify college preparatory courses (i.e., Algebra I but not general math) that they either have taken or plan to complete prior to graduating from high school. Students also provide detailed demographic and family background information. Multiple imputation techniques were used to fill missing data on student demographics and background (see Roderick J. A. Little, and Donald B. Rubin, *Statistical Analysis with Missing Data*. 2nd ed. [Hoboken, NJ: Wiley, 2002]). More detail can be found in Richard Buddin and Michelle Croft, "Do Stricter High School Graduation Requirements Improve College Readiness?" ACT Working Paper Series WP-2014-1 (Iowa City, IA: ACT, 2014), https://www.act.org/research/papers/pdf/wp-2014-1.pdf.

The analysis further relies on information for the 2005 through 2013 public high school graduation classes for all districts except for the Chicago Public School (CPS) district. CPS was omitted due to its size: there were 27,000 freshmen in CPS compared to 3,000 in the next largest district. The nine-year time span provides information on cohorts before the policy change, during the phase-in period, and after the implementation of the law.

ACT test data consists of 818,611 ACT Mathematics Test and ACT Science Test scores from the high school graduation classes of 2005 through 2013. Of these, about 24% claimed they were in the lowest half of their graduation class. About 10% of students did not report information on math or science courses taken.

8 Data on college enrollment was provided to ACT by the National Student Clearinghouse (NSC), which has enrollment information for over 96% of all students in public and private US postsecondary institutions. The college enrollment sample is 643,935. This smaller sample reflects enrollments through 2012 (2013 enrollments are not yet available from NSC). We were unable to match about 8% of students with NSC records (primarily due to missing Social Security Numbers).

9 Information on public school district graduation requirements was drawn from a 2005 Illinois State Board of Education Survey which the authors received through a Freedom of Information Act request. The survey asked whether districts met the overall requirements, the requirements in each subject area (English, math, and science), and if students in the districts take specific math courses proposed as part of the math requirement. About 87% of districts responded to the survey. Based on the survey results, districts were categorized into treated and untreated districts for each subject area (note that a district could be categorized as a treated district in science but not as a treated district in math). Treated districts were those that were affected by the law. Untreated districts were those that had implemented the same or more rigorous graduation requirements prior to the law's enactment.

10 ACT test records include students enrolled in private schools, but these students are omitted from our analysis for two reasons. First, private school students in the state take the ACT on a voluntary basis. This group may be unrepresentative of private school students in the state overall, as college enrollment is likely

the primary motivation of private school test takers. Second, the state school board survey was restricted to public school districts, so we have no information about private school graduation requirements in the baseline year of 2005.

11 David P. Gardner et al., *A Nation at Risk: The Imperative for Educational Reform* (Washington, DC: National Commission on Excellence in Education, 1983).

12 William H. Clune, Paula White, and Janice Patterson, *The Implementation and Effects of High School Graduation Requirements: First Steps Toward Curricular Reform*, Research Report Series RR-011 (New Brunswick, NJ: Center for Policy Research in Education, 1989); Elliott A. Medrich, Cynthia L. Brown, Robin R. Henke, and Lisa Ross, *Overview and Inventory of State Requirements for School Coursework and Attendance*, Report No. NCES 92-663, (Washington, DC: National Center for Education Statistics, 1992).

13 For instance, a study using NAEP and 1990 high school transcript data found that the majority of students completed more courses than required. Chaney, Burgdorf, and Atash, "Influencing Achievement."

14 For instance, Clune and White reviewed student transcripts in four states (California, Florida, Missouri, and Pennsylvania) at three points of time (two before and one after the implementation of new graduation requirements) to examine the effect of changing graduation requirements on student course taking. The study found a slight increase in core course taking for schools serving predominately low-achieving students. Likewise, Goodman found large increases in completed math coursework for African Americans, particularly for African American males, when using the High School and Beyond Survey for the classes of 1982, 1987, 1991, and 1994. William H. Clune and Paula White, "Education Reform in the Trenches: Increased Academic Course Taking in High Schools with Lower Achieving Students in States with Higher Graduation Requirements," *Educational Evaluation and Policy Analysis* 14, no. 1 (1992): 2–20; Joshua Goodman (2009). *The Labor of Division: Returns to Compulsory Math Coursework* (Cambridge, MA: HKS Faculty Research Working Paper Series, 2009), http://www.hks.harvard.edu/fs/jgoodma1/papers/mathcourses.pdf.

15 Lyle E. Jones, Ernest C. Davenport, Jr., Aloha Bryson, Tanja Bekhuis, and Rebecca Zwick, "Mathematics and Science Test Scores as Related to Courses Taken in High School and Other Factors," *Journal of Educational Measurement* 23, no. 1 (1986): 197–208, doi: 10.3102/01623737014001002; ACT, *Raising the Bar: A Baseline for College and Career Readiness in Our Nation's High School Core Courses.* (Iowa City, IA: ACT, 2012).

16 Justine Randunzel and Julie Noble, *Tracking 2003 ACT-Tested High School Graduates: College Readiness, Enrollment, and Long-Term Success* (Iowa City, IA: ACT, 2012).

17 Clifford Adelman, *The Toolbox Revisited: Paths to Degree Completion from High School Through College* (Washington, DC: US Department of Education, 2006).

18 Takoko Nomi and Elaine Allenworth, "'Double-Dose' Algebra as an Alternative Strategy to Remediation: Effects on Students' Academic Outcomes," *Journal of Research on Educational Effectiveness* 2, no. 2 (2009): 111–148.

19 Chrys Dougherty, Lynn Mellor, and Shuling Jian, *Orange Juice or Orange Drink? Ensuring That "Advanced Courses" Live Up to Their Labels*, NCEA Policy Brief No. 1 (Austin, TX: National Center for Educational Accountability, 2006), http://files.eric.ed.gov/fulltext/ED519415.pdf.