

Did raising the bar level the playing field?

Mathematics curricular intensification and inequality in American high schools, 1982-2004

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August 2011

Abstract: Over the last three decades, American high school students' course-taking has rapidly intensified. Between 1982 and 2004, for example, the proportion of high school graduates who earned credit in pre-Calculus or Calculus more than tripled. In this paper, we investigate the consequences of mathematics curricular intensification for social stratification in American high schools. Using representative data from U.S. high school graduates in 1982, 1992, and 2004, we estimate changes in race, class, and skills-based inequality advanced math course credit completion. Our analyses indicate that race, class, and skills gaps in Geometry, Algebra II, and Trigonometry completion have narrowed considerably over the study period. However, consistent with the theory of maximally maintained inequality, inequalities in Calculus completion remain pronounced.

Keywords: High school math, tracking, standards-based reform

American high schools are in the midst of rapid academic intensification. In 1982, fewer than one in five graduates from high schools in the United States earned credit in Trigonometry or a more advanced math course (Dalton et al. 2007). One year later, the Reagan administration's National Commission on Excellence in Education published *A Nation at Risk*, triggering the standards movement in American education. In the decades that followed, state and local educational policy-makers established content standards for K-12 schools, introduced high-stakes tests to measure whether or not students meet these standards, and raised high school graduation requirements. These policies ushered in a period of rapid academic intensification in American high schools (Clune & White 1992; Porter 1998; Schiller & Muller 2003). By 2004, nearly half of high school graduates earned credit in Trigonometry or a more advanced math course.

In this paper, we investigate the consequences of academic intensification for social stratification in American high schools. Academic intensification is an intended consequence of a broad-based policy effort to set high academic standards for all students. Proponents argue that standards-based school reforms equalize learning opportunities in American high schools by requiring schools to offer rigorous classes for all students and creating incentives for all students to succeed in these classes (c.f. National Governors Association 1990, 2005). But sociological theory and research suggests that educational inequalities can be stubbornly persistent, even in an era of educational expansion. Therefore, we ask in this paper whether recent efforts to raise the bar in American secondary education have leveled the playing field. To answer this question, we examine recent trends in racial, class-based, and skills-based inequalities in math course high school math course achievement. Our analyses, which use nationally representative data from US high school graduates in 1982, 1992, and 2004, focus particular attention on inequalities in access

to Calculus, the most advanced course in the math sequence in the vast majority of American high schools.

The standards movement and academic intensification

The push to expose all high school students to a core of rigorous academic coursework has deep roots in American education. In 1894, the National Educational Association's Committee of Ten argued that "every subject which is taught at all in a secondary school should be taught in the same way and to the same extent to every pupil" (NEA 1894, p. 17). However, this commitment wavered over the course of the 20th Century as high schools became mass institutions serving nearly all American youth. By mid-century, most American high schools were organized into overarching tracks, with a small number of students in academically-rigorous honors or college prep tracks and a larger number of students in less rigorous applied general or basic tracks (Lucas 1999). While high schools across the country dismantled these overarching tracks beginning in the 1960s and 1970s (Moore & Davenport 1988), most continued to stratify courses, allowing students to place into different levels in different subjects. Critics argue that this system undermined the curricular integrity of American high schools by allowing students to opt out of difficult academic courses (Powell, Farr, and Cohen 1985) even as it maintained class and race-based inequalities in high-level academic course-taking (Lucas 1999, Oakes 1985).

A Nation at Risk aimed to change this situation, proposing a more rigorous "New Basics" curriculum for all high school graduates. Published at a moment of rapid technological change and rising demand for highly skilled workers (Goldin & Katz 2008), the report hit a nerve. In the years immediately following its publication, states enacted an estimated 700 new pieces of educational policy, many of which raised standards for grade promotion and high school

completion (Darling-Hammond & Berry 1988; Timar & Kirp 1989; Wilson & Rossman 1993). By 2008, 25 states required students to satisfy the “New Basics” academic courses in order to earn a high school diploma (Education Commission of the States 2010)ⁱ and 24 states had implemented high school exit exams in order to certify that graduates have mastered basic academic skills (Center on Education Policy 2009).

Prior research suggests these standards-based policies pushed high school students into academically rigorous courses (Chaney, Burgdorf, & Atash 1997; Clune & White 1992; Conger, Long, Iatarola 2009; Porter 1998; Schiller & Muller 2002; White, Gamoran, Smithson, & Porter 1997). After two decades of reforms designed to improve the rigor of American schooling, nearly 95 percent of U.S. high schools graduates have completed at least one year of Algebra-level mathematics, and more than one third of U.S. high school graduates have completed coursework in pre-Calculus or Calculus (Dalton et al. 2007; Nord et al. 2011).

Academic intensification and high-level coursework

Following Sørensen (1970), we view curricular intensification as a form of detracking. Sørensen (1970) identifies four dimensions of school tracking: (1) *inclusiveness*, the extent to which high-level coursework is available to students; (2) *selectivity*, the extent to which tracking produces homogeneous learning environments; (3) *electivity*, the extent to which students can choose their own classroom placements; and (4) *scope*, the extent to which classroom placements in one academic subject are associated with classroom placements in other academic subjects (see also Gamoran 1996; Kelly 2007.) The curricular intensification that has occurred in American secondary school math curricula since the early 1980s has important implications for the track structure of American high schools. It has clearly increased the *inclusivity* of rigorous math courses. But what are the implications of curricular intensification for the *selectivity* of

mathematics track placements in American high schools? Our analyses ask whether the expansion of high-level math courses in American high schools have narrowed class-based, race-based, and skills-based inequalities in math course completion.

It seems reasonable to expect math course inequalities to narrow during a period of curricular intensification. Detracking advocates argue that standards-based school reforms provide a new legal justification for contesting curricular tracking practices in American high schools (Welner 2001). Furthermore, many prominent advocates of standards-based school reforms also call for the elimination of ability grouping in American high schools (c.f. National Governors Association 1990, 2005; National Council of Teachers of Mathematics 1989). When standards-based reforms establish a curricular bar that all students must clear, they encourage schools to eliminate lower-track and remedial courses. If doing so pushes students in the least rigorous courses to enroll in more advanced courses without influencing enrollment patterns for students already enrolled in more rigorous courses, rising standards will decrease track selectivity in American high schools.

However, raising the bar does not necessarily level the playing field. Indeed, recent research demonstrates that the educational advantages that white and high-status students enjoy persist despite the expansion of secondary and post-secondary educational opportunity (Raftery & Hout 1993; Gamoran 2001; Lucas 2001; Author 2010). Raftery and Hout's (1993) theory of maximally maintained inequality suggests that attainment gaps between children from high- and low-status groups persist until nearly all members of high-status groups reach a given attainment level. Only at this point – at which attainment rates for high-status youth can increase no further – do low-status youth begin to catch up and attainment gaps begin to narrow. For example, Raftery and Hout's analysis of educational attainment trends in Ireland indicate that class-based

gaps in secondary school attendance only began to narrow after secondary school attendance became nearly universal for children from high-status families.

Lucas (2001) extends this theory by integrating it with the literature on academic tracking. Prior to Lucas, work in the maximally maintained inequality tradition focused exclusively on inequalities in educational attainment levels. Lucas's theory of effectively maintained inequality acknowledges that these quantitative educational inequalities narrow when attainment levels reach a ceiling. However, Lucas argues at these moments of narrowing attainment inequality, youth in high-status groups exploit *qualitative* distinctions in order to maintain their advantage. For example, Lucas demonstrates that even as the universalization of secondary education causes class-based inequalities in high school diploma attainment to narrow; high-status students exploit qualitative distinctions such as college-preparatory track placement to maintain their advantages.

A large body of qualitative and case-study educational research conducted in schools supports Lucas's effectively maintained inequality hypothesis, documenting the array of structural and ideological factors that allow high-status parents to "work the system" (Wells & Oakes 1996, p. 137) and reproduce their social advantages. Yonezawa, Wells & Sarna (2002), for example, demonstrate the important role that information gaps play in reproducing social inequalities in high school course assignments. While advantaged parents are typically aware of tiered course patterns and the mechanisms for assigning students to advanced courses, less-advantaged parents often lack access to this information. This ethnographic tradition suggests that information inequalities help to maintain racial and class-based inequalities in the most advanced mathematics courses, especially since scheduling constraints severely limit schools ability to address course-placement inequalities once they emerge (Delany 1991). However,

Kelly's (2004) analyses of nationally representative cohort data suggest that parents rarely directly intervene in high school math course placements and "working the system" only explains a small portion of the class gap in high school math course enrollments.

While theories of maximally and effectively maintained inequality focus on racial and class-based inequality, the tracking literature also pays close attention to inequalities based on students' prior achievement. Tracking practices are based on an understanding of student intelligence as an innate and static. This widely-held theory of intelligence views variation in student achievement an indicator of variation in aptitude, suggesting that sorting students in homogenous groups based on their test scores maximizes instructional efficiency (Hallinan 1994). Oakes and colleagues argue that this fixed theory of intelligence often resonates with teachers' views (Oakes & Guiton 1995; Oakes, Wells, Datnow, & Jones 1997). As a result, even when policy provides incentives for schools to develop more inclusive curricula, this research tradition suggests that teachers and administrators will continue to sort students based on their prior achievement (Oakes & Guiton 1995; Oakes, Wells, Datnow, & Jones 1997; Sandholtz, Ogawa, & Scribner 2004; Wilson & Rossman 1993). This line of research complements sociological theories of maximally and effectively maintained inequality, suggesting that skills-based inequalities in advanced math course credits will persist even in an era of broad curricular intensification.

Hypotheses

Building on these theories of maintained inequality and the literature on academic tracking in secondary schools, this paper investigates the extent to which inequalities in high-level math course completion change in an era in an era of curricular intensification. This theoretical tradition holds that educational inequalities tend to persist even in periods of rising

educational opportunity. The theory of maximally maintained inequality focuses on educational attainment level gaps between advantaged and disadvantaged groups, suggesting these gaps only narrow when attainment rates for members of advantaged groups hit a ceiling and can grow no further. The theory of effectively maintained inequality suggests that similar processes occur within educational attainment levels, as members of advantaged groups exploit qualitative distinctions to maintain their privileged position during periods in which attainment inequalities are narrowing. Applied to mathematics course attainment patterns in American secondary schools, these theories suggest that class, race, and skills-based inequalities in relatively low-level academic math courses such as Algebra I and Geometry will narrow as enrollment rates for white, high-SES, and high-achieving students nears saturation. We hypothesize, therefore, that race, class, and achievement-based gaps in low-level academic math course enrollment were wider in 1982 than in 2004, net of potentially confounding demographic shifts.

However, this prediction does not apply at the top of the high school math course sequence. Even after more than two decades of curricular intensification, the rate of Calculus completion for students from advantaged groups has not reached a ceiling. Until this occurs, theories of maintained inequality suggest that Calculus course completion rates for advantaged students will tend to grow at least as fast as enrollment rates for less advantaged groups. We hypothesize, therefore, that race, class, and achievement-based gaps in the probability of enrolling in high-level academic math courses for 1982 graduates are equal to or smaller than these gaps for 2004 graduates.

Data and methods

In this paper, we first document the intensification of math course-taking patterns among American high school graduates between 1982 and 2004. We then investigate changing

inequalities in math course-taking patterns between the early 1980s and the early 2000s to test the above “maintained inequality” hypotheses. Our analyses focus on two distinct forms of inequality in math course-taking patterns. First, we analyze trends in demographic inequality, looking at changing variation in math course-taking patterns by race and class over time. Second, we examine shifts in the distribution of student test scores by math course attainment over the study period to better understand changes in skills-based inequality.

Our analyses rely on data from the High School and Beyond (HS&B) survey, the National Educational Longitudinal Study of 1988 (NELS:88) and the Educational Longitudinal Study of 2002 (ELS:2002). Together, these studies provide nationally representative longitudinal student-reported survey data, as well as test score and transcript data for three cohorts of US high school students educated between the early 1980s and the 2000s. The HS&B is based on a sample of approximately 30,000 1980 high school sophomores. Although the NELS is based on a representative sample of 24,000 8th graders, the study surveyed a “freshened” nationally-representative sample of high school sophomores in 1990. The ELS started in 2002 with a sample of nearly 18,000 high school sophomores.ⁱⁱ To maximize cross-cohort comparability in the analyses that follow, we use data only from on-time high school graduates from the HS&B, NELS, or ELS 12th grade cohort for whom full transcript data were available, following the procedures outlined in Dalton et al. (2007).ⁱⁱⁱ All analyses are weighted using NCES-created transcript data weights.^{iv} In addition, all statistical analyses use the Stata “cluster” subcommand to correct standard errors for the non-independence of HSB, NELS and ELS respondents who are enrolled in the same school.

Following Lucas (2001), our analyses focus on math course enrollment trends. While tracking occurs in other subject areas as well, tracks are particularly apparent in mathematics.

Math course titles are clearly sequenced, and in nearly all American high schools, students progress from general math, to Algebra I, Geometry, Algebra II, Trigonometry/Pre-Calculus, and Calculus. Accordingly, a student's most advanced math course credit provides a reliable indicator of his or her mathematics track placement. In each of the three cohorts, we use Classification of Secondary School Course codes (CSSC) to sort students into one of seven categories describing the most advanced math course in which they earned any course credit: (1) Students completed no math, students whose highest math course was remedial, pre-Algebra or another non-academic math course; (2) students who completed Algebra I; (3) students who completed Geometry; (4) students who completed Algebra II; (5) students who completed Trigonometry; (6) students who completed pre-Calculus; (7) students who completed Calculus.^{v,vi}

Our analyses focus on racial, class, and skills gaps in math course-taking patterns and how these gaps have changed over time. We use composite variables from each of the three datasets to sort students into five racial/ethnic categories: white, black, Hispanic, Asian, and other.^{vii} Although we do not focus on gender inequalities here, our analyses also use composite variables from each of the three datasets to identify students' gender.^{viii} Finally, we use NCES-computed composite variables measuring students' socio-economic status at the 10th grade (which are, in turn, based on the information that students provide about their parents' educational attainment, occupation, and income) as an indicator of student class background.^{ix} In all three datasets, SES is calculated as the mean of the z-scored values of the following variables: Father's educational attainment, mother's educational attainment, father's occupational prestige, mother's occupational prestige, and family income. This SES composite measures student status relative to cohort peers, rather than relative to students in other cohorts. Therefore, although

secular demographic shifts cause distribution of parental education and family income to change across the three samples, the distribution of the SES measure is very similar across the three datasets.

To capture trends in skills-based inequality, we draw upon cohort-equated 10th grade mathematics test scores, which are available from NCES on a restricted use license. While the test batteries administered to students in these three cohorts are not identical, 16 quantitative comparison items from the mathematics test administered to HSB 10th graders are included in the NELS and ELS 10th grade mathematics achievement tests. To generate the cohort-equated 10th grade mathematics test scores, NCES technicians estimated item response theory (IRT) parameters for the 16 common items using the NELS sophomore sample, and then placed non-overlapping HSB and ELS items on that IRT scale. (For more detail on the equating procedure, see Ingels, Rogers, Siegel, and Stutts 2004 and Cahalan, Ingels, Burns, Planty, Daniel, & Owings 2006). Values for this cohort-equated IRT math test score represent the sum of students' odds of correctly answering each of the 58 items that appeared on the multiform 1990 NELS mathematics test, ranging from approximately 10 to 58.

In addition to describing math course-taking trends and changes in demographic and skills-based inequalities in high-status academic math course completion, we fit multivariate models to isolate the independent influence of demographics, skills, and student track location from math course-taking patterns for students in the three cohorts. These models, which are estimated on stacked HSB, NELS, and ELS data, employ a series of cohort*independent variable interaction terms to explicitly model changes in demographic and skills-based inequality that occur over the study period. We think of graduates' highest math course as an ordinal variable, since there is a clear status and difficulty hierarchy ranging from remedial or non-academic math

at the bottom to Calculus at the top. Accordingly, we use ordered logistic regression models to estimate changing inequalities in math course completion.

While these analyses provide a parsimonious way to understand changes in the curricular organization of schools, their validity hinges on the assumption that the relationship between independent variables and student math course taking is consistent across the math course distribution. This assumption is inconsistent with our application of the theories of maximally and effectively maintained inequality, both of which suggest that inequalities in high-status course completion will be more persistent than inequalities in lower-level math courses. Furthermore our analyses reveal that the parallel regression assumption does not hold at the top of the math course distribution.^x Therefore, we also report logistic regression models in which the dependent variable distinguishes between students who earned Calculus credit and students who did not. If inequalities in calculus completion change less over the study period than inequalities across the math course distribution, these models support the theory of maximally and effectively maintained inequality.

In addition to controlling for student demographics, test scores, and self-reported track placement, our ordered logistic models control for school sector. Throughout the study period, students in Catholic and other private schools have tended to enroll in more high-level math courses than their peers in public schools. Our sector controls are designed to insure that changes in student enrollment patterns over the study period do not obscure changes in course-taking patterns.^{xi}

Findings

Academic intensification, 1982-2004

Table 1 provides a descriptive summary of American high school students' math test scores, graduation rates, and course-taking patterns in the early 1980s, 1990s, and 2000s. This table demonstrates that the course-taking patterns of American high school students changed dramatically over these decades. Just 2 percent of 1982 high school graduates had completed the necessary courses to satisfy the commission's "New Basics" high school curriculum. Over the next two decades, the proportion of graduates completing this academically intensive curriculum increased tenfold. Sixteen percent of the high school class of 1992 and 30% of the 2004 high school class satisfied the "New Basics" curriculum.

TABLE 1 ABOUT HERE

Consistent with this trend toward academic intensification, the median class of 2004 high school graduate completed 4.5 more Carnegie units of academic coursework than the median class of 1982 high school graduate. The increase is particularly pronounced in math and science courses, where the median class of 2004 high school graduate earned a full Carnegie credit more in each subject than the median 1982 high school graduate. The standard deviation figures in Table 1 show a modest decline in the amount of between-student variation in course credit completion between 1982 and 2004. This trend is consistent with the implementation of more rigorous graduation requirements that have narrowed curricular differences between students who enrolled in academically intensive course sequences and students who did not.

The last row in Table 1 reveals a modest improvement in the skills base for U.S. high school students over the study period. The mean IRT-equated math test score for students in the class of 2004 was nearly 4 points higher than the mean for students in the class of 1982, a difference that is equal to approximately one-fourth of a standard deviation. More detailed analyses indicate that this test score growth was more pronounced at the bottom of the

distribution. For example, the score for students at the 25th percentile score on this exam improved nearly 6 points between the 1982 cohort and the 2004 cohort.^{xii}

Table 2 provides further insight into the academic intensification of American high school curricula by focusing on trends in math course enrollments. In addition to completing more academic credits, high school graduates in the class of 2004 completed more credits in advanced academic courses compared to graduates in the class of 1982. This curricular upgrading occurs throughout the course distribution. Nearly 20 percent of class of 1982 high school graduates earned their diploma without having taking pre-algebra or any other higher level math course, compared to just 7 percent of the class of 1992 and the class of 2004. But the expansion in high-level math course enrollments that occurred during this period is particularly pronounced. In the class of 1982, advanced math course enrollments were limited to elite students. Approximately 19 percent of 1982 graduates earned credit in Trigonometry or a higher math course; and just five percent earned credit in Calculus. One-third of 1992 high school graduates completed Trigonometry or a higher math course, and nearly 11 percent completed Calculus. By 2004, 43 percent of high school graduates completed Trigonometry or a higher math course; 14 percent completed Calculus.

TABLE 2 ABOUT HERE

Changes in math course taking inequality, 1982-2004

What implications did this intensification of high school math curricula have for demographic and skills-based inequalities in advanced math coursework? In the analyses that follow, we first investigate inequalities across the math course sequence using a series of ordinal logistic regression models. Then, building on maintained inequality theories – which hold that inequalities in the most high-status courses are more durable than inequalities in lower-level

math courses – we estimate a series of logistic regression analyses focusing on changes in Calculus credit-earning.

TABLE 3 ABOUT HERE

Model 1 of Table 3 provides a multivariate overview of the factors that predict math course placement. These findings clearly indicate that the trend toward academic intensification represented in Table 2 is not simply driven by demographic or other changes in the composition of high school graduates. All else equal, class of 1992 graduates are significantly more likely to earn credits in advanced math courses than class of 1982 graduates, and this trend is even more pronounced for class of 2004 graduates. The multivariate results suggest that SES and 10th grade math test scores positively predict math course enrollment. The significant positive SES-squared term indicates that the positive relationship between SES and math course taking is particularly pronounced at the top of the SES distribution. Similarly, the significant positive squared and cubed terms for math test scores indicate that math test scores are especially predictive of course placements for high-achieving students. Net of these factors, Black, Hispanic, and Asian students are significantly more likely to enroll in advanced math courses than are whites; and males are less likely to enroll in advanced math courses than females. These findings parallel Long, Conger, and Iatorola's (2009) and Kelly's (2009) findings on racial inequality in high school math course placement.

The remaining models in Table 3 add multiplicative interaction terms to model changes in the relationship between these predictors and student math course taking across the three cohorts. The Model 2 investigates the changing relationship between race and graduate math course completion. This model also reveals that the rates of enrollment in advanced math courses grew faster for blacks and Hispanics between 1982 and 2004 than for whites. The Model 3

results suggest that the relationship between SES and math course taking patterns weakened between 1982 and 2004. While math course-taking patterns continue to be stratified by family SES in the class of 2004, the significant and negative class of 2004 * SES interaction suggests that low-SES students benefitted disproportionately from the trend toward academic intensification that occurred between 1982 and 2004. Similarly, the results reported in Model 4 suggest that the relationship between 10th grade math test scores and graduates' ultimate math course completion shifted between 1982 and 2004. The negative and significant test score * class of 2004 coefficient suggests that the relationship between test scores and math course completion was less pronounced for this most recent cohort compared to graduates in the class of 1982.

TABLE 4 ABOUT HERE

Table 4 illustrates these changes in high school math curricula. In this, we draw upon the regression model reported in Table 3 to isolate changes in Algebra II completion rates in each of these categories from potentially confounding changes in other areas. These analyses indicate that even after controlling for changes in family background and 10th grade test scores, black and Hispanic students' odds of completing Algebra II grew faster between 1982 and 2004 than did white students' odds. For example, this table indicates that Hispanic graduates in the class of 1982 were approximately 3.5 percentage points less likely to complete Algebra II than white peers with similar family backgrounds and 10th grade test scores. But between 1982 and 2004 that gap reversed, and Hispanic graduates in the class of 2004 were seven percentage points more likely to complete Algebra II than whites with similar family backgrounds and prior test scores. We find similar evidence to suggest that curricular intensification disproportionately boosted low-SES students' Algebra II completion rates, and the gap in Algebra II completion rates between high SES and low SES students narrowed from 16 to 11 percentage points between

1982 and 2004. The changes in skills-based inequality in Algebra I completion summarized in Table 4 are particularly remarkable. In 1982, students with high 10th grade test scores were approximately four times as likely to finish Algebra II as students with low 10th grade test scores, net of SES and race. Between 1982 and 2004, however, the Algebra II completion rate for low-skill students surged by nearly 30 percentage points, and by 2004, high-skills students were less than twice as likely to complete Algebra II than comparable students with below-average 10th grade math test scores.

Focus on Calculus

The ordered logistic models reported in Table 3 provide a useful multivariate overview of advanced math course taking trends. However, these models assume that the relationship between the independent variables and math course completion is consistent across the math course sequence. This assumption is both theoretically and empirically untenable. Theoretically, the notion of maximally and effectively maintained inequality implies that inequalities in Calculus completion may persist even as inequalities in credit-earning at lower levels in math course hierarchy narrow. Empirically, the Brant Test of Parallel Regression rejects the proportional odds assumption, indicating that the predictors of high-level course completion are not equivalent to the predictors of low-level course completion. Therefore, in Table 5 we focus on changing inequalities in Calculus completion.

TABLE 5 ABOUT HERE

The baseline results reported in Model 1 of Table 5 are largely consistent with the ordered logistic regression model reported in Model 1 of Table 3. Across the three cohorts, we find that men are slightly less likely to enroll in Calculus than women, while African-Americans and Asians are more likely than whites to enroll in Calculus. The association between student

SES and Calculus enrollment odds is strong and positive; as is the association between 10th grade math test scores and Calculus course completion. Finally, the significant positive coefficients for the Class of 1992 and Class of 2004 cohort dummies indicate that student odds of completing Calculus credits have increased over time, even after controlling for demographic and skills-based changes.

But in contrast to the ordered logistic regression models reported in Table 3, we find that demographic and skills-based inequalities in Calculus course completion have persisted over the last three decades. Model 2 of Table 4 provides no evidence to suggest that racial inequalities in Calculus credits narrowed between 1982 and 2004.^{xiii} Model 3 of Table 4 indicates that class-based gaps in Calculus credit also remained unchanged during the study period. Furthermore, we find some evidence in Model 4 of Table 4 to suggest that skills-based gaps in Calculus *widened* during the study period. This last finding is striking. During a period in which more and more students are earning Calculus credits, one might expect the course to become more widely available to students with unexceptional prior math test scores, weakening the association between Calculus credits and 10th grade math test scores. However, our analyses suggest that the opposite has occurred. Students' 10th grade math scores are significantly more predictive of their odds of earning Calculus credits in 2004 than 1982.

TABLE 6 ABOUT HERE

Table 6 illustrates these findings, reporting regression-corrected Calculus completion rates for 1982, 1992, and 2004 graduates by race/ethnicity, SES, and 10th grade math test scores. As this table makes clear, Calculus completion rates increased for all racial and SES groups between 1982 and 2004. However, racial and class-based gaps in Calculus completion remained largely unchanged over the study period. Calculus completion rates in for blacks and Hispanics

more than doubled between 1982 and 2004. However, Calculus completion rates for whites increased at approximately the same rate over the study period, and racial inequalities in Calculus completion did not change dramatically between 1982 and 2004. Class-based inequalities in Calculus completion also persisted across the three cohorts. The Calculus completion rate grew substantially for low-SES high school graduates over the study period. However, it grew more rapidly for high-SES graduates and the Calculus completion gap between low-SES and high-SES students remained largely unchanged over the study period.

While Calculus completion rates improved across racial and class lines between 1982 and 2004, Table 6 indicates that low-achieving students did not participate in this expansion of Calculus course-taking. Holding student race and SES constant, the proportion of high-achieving high school graduates who earned Calculus credits more than doubled between 1982 and 2004, from 13 to 28 percent. However, in the same time period, the proportion of graduates who scored one standard deviation below the mean on the 10th grade math test remained stuck below 1 percent. As a result, skills-based inequalities in Calculus completion – already pronounced in 1982 – widened between 1982 and 2004. This finding suggests that although academic intensification allowed students with a broader range of prior skills to enroll in and complete other academic math courses, schools did not relax the academic selection criteria for Calculus courses. Instead, consistent with the theory of maximally maintained inequality, we find that Calculus courses became more academically selective during the study period.

Conclusion

The curricular organization of American high schools has changed dramatically in the decades since *A Nation at Risk*. The average class of 2004 high school graduate earned approximately 5 more academic credits than the average class of 1982 graduate, and the

proportion of students who enrolled in advanced math courses grew particularly rapidly during this period. In light of these profound shifts, this paper draws upon the theories of maximally and effectively maintained inequality to investigate changes in racial, class, and skills inequalities in academic math course completion over the same period. We hypothesize that low-level math course completion rate inequalities narrow during periods of curricular intensification, while gaps in high-level math course completion rates are more persistent. Our findings bear these hypotheses out, pointing to two divergent trends: On one hand, inequalities in Algebra, Geometry, Algebra II, Trigonometry, and Pre-Calculus course completion narrowed considerably over the study period. On the other, inequalities among students who complete Calculus, the most advanced mathematics course that is broadly available to American high school students, are strikingly persistent.

By requiring students to meet higher academic standards to graduate, standards-based school reforms reduced the amount of electivity in American secondary school math curricula and boosted the inclusiveness of college-preparatory math courses. Our multivariate analyses suggest the national trend toward academic intensification disproportionately influenced the math course completion patterns for African-American, Hispanic, and low-SES students. Likewise, we find that math course completion patterns intensified more rapidly for low-achieving students during the study period than they did for high-achieving students. Accordingly, our analyses clearly indicate that the nationwide push to increase academic math course enrollments substantially reduced the degree of racial, class, and skills-based selectivity in high school math credit-earning.

However, racial, class, and skills-based inequalities are far more persistent at the top of the American secondary math course sequence. Calculus course-completion rates increased

particularly dramatically during this period of curricular intensification. Between 1982 and 2004, the proportion of high school graduates who earned Calculus credits nearly tripled, growing from 5 percent to 14 percent. However, racial, ethnic, class-based, and skills-based inequalities in Calculus credit persisted over the study period. In fact, we find that students with relatively high 10th grade math skills largely drove this expansion in Calculus course completion rates. As a result, our analyses indicate that skills-based inequalities in Calculus completion *widened* between the class of 1982 and the class of 2004. In the class of 1982, a student who scored one standard deviation above the mean on the 10th grade math test was approximately 6 times more likely than a demographically similar student with average 10th grade math test scores to earn Calculus credits before graduating. By the class of 2004, that skills-based gap in Calculus had widened to 7 times. While curricular intensification has opened opportunities for students with relatively low levels of prior achievement to take and complete college-preparatory math courses, Calculus credits remain remarkably restricted to relatively high-achieving students.

Our findings suggest that after more than two decades of standards-based school reforms, American high school students are, indeed, completing more academic math courses and reaching higher levels of math course completion. These gains are widespread. White students as well as students of color; affluent students as well as poor students; high-achieving students as well as low-achieving students are all taking more advanced math courses today than they were three decades ago. However, the divergent findings for Calculus speak to the limitations of curricular intensification as a strategy for narrowing educational inequalities. Rather than eliminating the tiered and socially unequal track structure of American high schools, the trend toward academic intensification that occurred over the last several decades reproduced that hierarchy at a more advanced level.

These analyses, therefore, expand the theories of maximally and effectively maintained inequality to explain inequalities in course completion as well as inequalities in degree attainment. While recent trends in high school mathematics course-taking patterns clearly indicate that efforts to raise the academic demands on students can bear fruit, we find that the advantages that white students and students from high-SES backgrounds, and high-performing students enjoy are remarkably persistent. Furthermore, although prior work in the maximally and effectively maintained inequality tradition has focused primarily on race and class gaps, our analyses indicate that similar patterns hold for inequalities based on prior skills.

One central question that our analyses do not address involves the effects of mathematics curricular intensification on the distribution of student achievement. The push to enroll more students in academic mathematics courses is clearly driven by an interest in narrowing achievement gaps by exposing low-achieving students to more challenging course environments. However, evaluations of district-level efforts to eliminate remedial mathematics coursework and require all students to enroll in college preparatory coursework return mixed results (Allensworth, Nomi, Montgomery, & Lee 2009; Burris, Heubert, & Levin 2006; Burris, Wiley, Welner, & Murphy 2008). Furthermore, our findings suggest that even in the face of these efforts, the highest-achieving students continue to complete more high-level coursework than their lower-achieving peers. While comparability issues plague comparisons of 12th grade math test data from the HSB, NELS, and ELS, we hope future research will address the effects of curricular intensification on student achievement.

Author. (2010).

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Table 1: Trends in high school graduation and academic credit completion, 1982-2004

	Class of 1982			Class of 1992			Class of 2004		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
On-time graduates:									
% satisfy "New Basics" requirements	2.32	--	--	16.32	--	--	31.92	--	--
# academic courses	14.62	14	4.07	15.44	15.5	3.38	19.07	19	3.69
# Mathematics courses	2.65	2.5	1.24	3.22	2.5	0.93	3.4	3.5	1.04
# English courses	3.96	4	1.03	4.09	4	0.78	3.86	3.5	1.1
# Science courses	2.27	2	1.23	2.93	3	1.05	3.08	3	0.99
# Social Studies courses	3.24	3	1.06	3.48	3.5	0.91	3.62	3.5	1
All 10th graders:									
% earn on-time diploma	79.87	--	--	77.52	--	--	78.15	--	--
IRT # right, 10 th grade math test	34.03	34.12	12.24	36.18	37.12	12.10	37.88	38.72	11.17

Notes:

Class of 1982: High School and Beyond (HSB), weight= TRWT;

Class of 1992: National Education Longitudinal Survey (NELS), weight=F2TSCWT

Class of 2004: Education Longitudinal Study of 2002 (ELS), weight= F1TRSWT

Table 2: Trends in highest math course credit completion; 1982, 1992, and 2004 on-time high school graduates

	Class of 1982		Class of 1992		Class of 2004		Δ 1982- 2004	2004:1982 ratio
	%	N ^{xiv}	%	N	%	N		
Remedial	20.12	1,740	8.24	1,090	7.25	690	-12.87	0.36
Algebra I	22.60	2,080	18.04	2,290	6.89	640	-15.71	0.30
Geometry	15.59	1,730	15.15	2,150	13.93	1,390	-1.66	0.89
Algebra II	22.84	2,550	27.81	3,870	28.53	3,050	5.69	1.25
Trigonometry	8.57	1,110	10.67	1,550	10.46	1,200	1.89	1.22
Pre-Calculus	4.91	580	10.16	1,790	18.83	2,230	13.92	3.84
Calculus	5.37	670	9.93	1,920	14.11	1,850	8.74	2.63

Notes:

Class of 1982: High School and Beyond (HSB), weight= TRWT;

Class of 1992: National Education Longitudinal Survey (NELS), weight=F2TSCWT

Class of 2004: Education Longitudinal Study of 2002 (ELS), weight= F1TRSWT

Table 3: Ordered logistic regression coefficients. Predictors of highest math course credits, with interactions to model cross-cohort change; 1982, 1992, and 2004 on-time high school graduates

	Model 1: Base	Model 2: Race, gender * cohort	Model 3: SES*cohort	Model 4: Math test* cohort
Male	-0.235***	-0.184**	-0.237***	-0.234***
Black	0.456***	0.183+	0.459***	0.450***
Hispanic	0.189***	-0.128+	0.182**	0.183***
Asian	0.778***	1.297***	0.772***	0.777***
Other	-0.063	-0.408+	-0.064	-0.070
SES (std)	0.355***	0.357***	0.397***	0.356***
SES2 (std) ²	0.078***	0.074***	0.074***	0.077***
Missing SES	-0.296*	-0.271*	-0.303*	-0.291*
Math test (std)	1.309***	1.330***	1.314***	1.355***
Math test(std) ²	0.290***	0.295***	0.292***	0.292***
Math test (std) ³	0.129***	0.124***	0.128***	0.126***
Missing math	-0.385*	-0.401*	-0.385*	-0.386*
Catholic school	0.778***	0.787***	0.780***	0.777***
Other private school	0.524**	0.533***	0.519**	0.523**
Missing school	-0.263	-0.223	-0.256	-0.269
Class of 1992	0.835***	0.772***	0.840***	0.830***
Class of 2004	1.271***	1.226***	1.267***	1.272***
Male*1992		0.051		
Male*2004		-0.199**		
Black*1992		0.182		
Black*2004		0.620***		
Hisp*1992		0.384**		
Hisp*2004		0.574***		
Asian*1992		-0.875***		
Asian*2004		-0.377+		
Other*1992		0.453		
Other*2004		0.532+		
SES*1992			0.006	
SES*2004			-0.128**	
Math*1992				-0.005
Math*2004				-0.114*
R-square	.1747	.1761	.1750	.1749
N=	34,120	34,120	34,120	34,120
	+p<0.10	*p<0.05	**p<0.01	***p<0.001

Notes:

Class of 1982: High School and Beyond (HSB), weight= TRWT;

Class of 1992: National Education Longitudinal Survey (NELS), weight=F2TSCWT

Class of 2004: Education Longitudinal Study of 2002 (ELS), weight= F1TRSWT

Table 4: Regression-predicted Algebra II completion rates for US high school graduates in the class of 1982, 1992, and 2004, by Race, SES, and 10th grade math test score.

	Class of 1982	Class of 1992	Class of 2004	Δ 1982-2004
Race				
White	49.95	71.80	78.26	28.31
Black	59.00	73.92	90.35	31.35
Hispanic	46.36	72.33	85.10	38.74
Asian	79.34	79.12	86.44	7.1
SES				
-1 SD	43.95	61.18	72.31	28.36
Mean	49.50	69.56	76.54	27.04
+1 SD	60.13	80.31	83.38	23.25
10 th grade math test				
-1 SD	21.65	36.87	50.21	28.56
Mean	48.47	68.86	75.64	27.24
+1 SD	81.00	91.77	92.72	11.72

Notes:

Class of 1982: High School and Beyond (HSB), weight= TRWT;

Class of 1992: National Education Longitudinal Survey (NELS), weight=F2TSCWT

Class of 2004: Education Longitudinal Study of 2002 (ELS), weight= F1TRSWT

Course enrollment probabilities predicted from Table 3 ordered logistic regression model, all controls held constant at sample mean

Table 5: Logistic regression coefficients. Predictors of Calculus course credits, with interactions to model cross-cohort change; 1982, 1992, and 2004 on-time high school graduates

	Model 1: Base	Model 2: Race, gender * cohort	Model 3: SES*cohort	Model 4: Math test* cohort
Male	-0.182**	-0.086	-0.18**	-0.18**
Black	0.396*	0.136	0.40*	0.41*
Hispanic	0.159	0.134	0.16	0.16
Asian	0.873***	0.910***	0.87***	0.88***
Other	0.048	-0.364	0.05	0.05
SES (std)	0.221***	0.225***	0.26**	0.22***
SES2 (std) ²	0.095**	0.093**	0.09**	0.10***
Missing SES	-0.295	-0.268	-0.29	-0.29
Math test (std)	1.691***	1.694***	1.69***	1.41***
Math test(std) ²	0.362***	0.363***	0.36***	0.34***
Math test (std) ³	0.129+	0.127+	0.13+	0.15*
Missing math	1.106***	1.085**	1.12***	1.27***
Catholic school	0.336*	0.339*	0.34*	0.34*
Other private school	0.533+	0.537+	0.53+	0.54+
Missing school	0.198	0.259	0.21	-0.21
Class of 1992	0.622***	0.677***	0.63***	0.19
Class of 2004	0.907***	0.948***	0.94***	0.63***
Male*1992		-0.088		
Male*2004		-0.145		
Black*1992		0.561		
Black*2004		0.100		
Hisp*1992		-0.201		
Hisp*2004		0.152		
Asian*1992		-0.444		
Asian*2004		0.248		
Other*1992		-0.655		
Other*2004		0.529		
SES*1992			-0.01	
SES*2004			-0.08	
Math*1992				0.47**
Math*2004				0.30*
Constant	-4.318***	-4.360***	-4.34***	-4.05***
R-square	0.3179	0.3191	0.3180	0.3308
N=	34,120	34,120	34,120	34,120
	+p<0.10	*p<0.05	**p<0.01	***p<0.001

Notes:

Class of 1982: High School and Beyond (HSB), weight= TRWT;

Class of 1992: National Education Longitudinal Survey (NELS), weight=F2TSCWT

Class of 2004: Education Longitudinal Study of 2002 (ELS), weight= F1TRSWT

Table 6: Regression-predicted Calculus completion rates for US high school graduates in the class of 1982, 1992, and 2004, by Race, SES, and 10th grade math test score.

	Class of 1982	Class of 1992	Class of 2004	Δ 1982-2004
Race				
White	2.08	4.02	5.21	3.13
Black	2.38	7.76	6.51	4.13
Hispanic	2.38	3.77	6.82	4.44
Asian	5.02	6.26	14.88	9.86
Social Class				
-1 SD	1.77	3.31	4.77	3
Mean	2.1	3.87	5.22	3.12
+1 SD	2.96	5.38	6.76	3.8
10th grade math test				
-1 SD	0.66	0.50	0.91	0.25
Mean	2.22	2.67	4.08	1.86
+1 SD	13.14	22.56	27.70	14.56

Notes:

Class of 1982: High School and Beyond (HSB), weight= TRWT;

Class of 1992: National Education Longitudinal Survey (NELS), weight=F2TSCWT

Class of 2004: Education Longitudinal Study of 2002 (ELS), weight= F1TRSWT

Course enrollment probabilities predicted from Table 5 logistic regression model, all controls held constant at sample mean

ⁱ The curricular requirements for this count exclude the half year of computer science included in the “New Basics” curricula, since data on state computer science requirements are not widely available. <http://mb2.ecs.org/reports/Report.aspx?id=735>

ⁱⁱ While these studies were designed to facilitate cross-cohort comparisons, they define their cohorts in somewhat different ways. The NELS and ELS studies both refreshed their follow-up samples to be representative of US high school sophomores and seniors despite sample attrition. However, the 1982 HS&B follow-up study did not refresh its sample to correct for student attrition. However, NCES analyses (Dalton et al. 2007) indicate that this difference is sample construction does not bias cross-cohort trend analyses using these data.

ⁱⁱⁱ HS&B students are included in the analyses if HSDIPLOM=1, they had earned at least one course credit in high school English (CTI3>0) and they graduated from high school between August 1981 and October 1982 (based on the variable DTLEFT). NELS students are included if they are in the on-time 12th grade cohort (G12COHRT=1 or =2), graduated high school on-time (F2RTOUT=1 or 2) have full transcript data (F2TRSCFL=1) and at least one course credit in high school English (F2RHEN>0). Similarly the ELS sample includes students in the 12th grade cohort (G12COHRT=1) who earned on-time diplomas (F1RTROUT=1, 2, 3, or 4) in 2004 (based on F1RDTLFT), have full transcript data (F1TRFLG>=1) and have completed at least one course credit in English (F1RENG_C>0).

^{iv} TRWT in HS&B, F2TSCWT in NELS, and F1TRSWT in ELS.

^v It should be noted that our analyses are based on course titles and course catalogue descriptions, rather than direct measurement of course content. Neither the HS&B, the NELS, nor the ELS provide the necessary data to determine whether or not course content changed over time. This introduces a possible source of bias into our analysis, if schools simplify course content as more and more students enroll in advanced academic courses (Dougherty, Mellor, & Jian 2006).

^{vi} Our highest math categorical variables are based on summary variables constructed by NCES staff from the high school transcript files. The HS&B highest math variable is based on student responses to the variables HSTSMA_1, HSTSMA_2, HSTSMA_3, HSTSMA_4, HSTSMA_5, HSTSMA_6, HSTSMA_7, and HSTSMA_8. The NELS variables are based on F2RAL1_C, F2RGEO_C, F2RAL2_C, R2RTRI_C, F2RPRE_C, and F2RCAL_C (from the N2R release). Information on remedial course enrollment for NELS students comes from HSREMAT (from the NOT release). Similarly, the ELS variables are based on F1RAL1_C, F1RGEO_C, F1RAL2_C, F1RTRI_C, F1RPRE_C, F1RCAL_C. In addition, we used data from the ELS variable F1RMAPIP to categorize students who took only remedial or non-academic math (F1RMAPIP=1 or 2) and students who took pre-Algebra (F1RMAPIP=3). The documentation is somewhat limited for the HS&B transcript variables. However, careful examination of the documentation for the NELS and ELS variables reveal only minor variations in variable definition between the two later studies. The most important distinction between the NELS and ELS variable definition involves remedial math courses. The NELS remedial math definition is somewhat more inclusive than the ELS remedial math definition, and although consumer math courses are counted as remedial in the NELS, they are in the other category in the ELS. As a result, these data may understate the proportion of class of 2004 students in remedial math, relative to earlier cohorts.

^{vii} The HSB and NELS source variable that we use is “RACE”; the ELS source variable is “BYRACE.” In each case, these variables are based primarily on students’ survey self-identification, but use data from other sources such as the survey roster, parent race, or student surname and/or native language when racial data are otherwise unavailable.

^{viii} “SEX” in HSB and NELS; “BYSEX” in ELS.

^{ix} “BYSES” in HSB; “F1SES” in NELS; “BYSES1” in ELS.

^x The Brant Test of Parallel Regression reveals that the relationship between virtually several of the independent variables and student math course trajectory differs significantly at the top of the math course distribution.

^{xi} We additionally estimated all analyses separately for public school students only. The results are not substantively different from those reported here.

^{xii} Table 1 also indicates that the trend toward increasingly rigorous high school curricula is not an artifact of a broad-based change in the pool of high school graduates, such as might occur if high school graduation rates declined. Consistent with other research on recent trends in high school completion (Heckman & LaFontaine 2010), data from the HSB, NELS, and ELS reported in Table 1 indicate that the proportion of US 10th graders who go on to finish high school on time has remained fairly consistent over the last several decades.

^{xiii} While not central to this paper’s research question, it is interesting to note that the male advantage in Calculus course completion also persisted over the study period. In a period in which girls surged ahead of boys on a wide range of educational measures (c.f. Buchmann & DiPrete 2006), this analysis indicates that gender inequalities in high school Calculus course completion did not change significantly.

^{xiv} In compliance with NCES restricted data licensing agreements, the number of cases in each of the cells of this table and all subsequent tables is rounded to the nearest 10.