

## Math Articulation Between the San Francisco Unified School District and the City College of San Francisco

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### Background

San Francisco's Bridge to Success (BtS) initiative brings together the City and County of San Francisco, the San Francisco Unified School District (SFUSD), the City College of San Francisco (CCSF), and key community organizations to promote postsecondary success for underrepresented students. Six working groups, each comprised of staff from both SFUSD and CCSF and focused on a different part of students' educational trajectories, can request analyses from the John W. Gardner Center for Youth and Their Communities (JGC) at Stanford University that are used to make policy or programmatic change to improve youth outcomes. At the request of the "math teaching" team, the JGC used its Youth Data Archive to conduct this analysis, which focuses on the relationship between students' high school math performance at SFUSD and their performance on CCSF's math placement test for incoming students. Research by CCSF has highlighted the importance of this initial placement test, as students who place below college-level math are less likely to advance through the sequence of remedial courses and to complete necessary transfer-level courses to enter a four-year institution (City College of San Francisco, 2010).

Key findings from this analysis include:

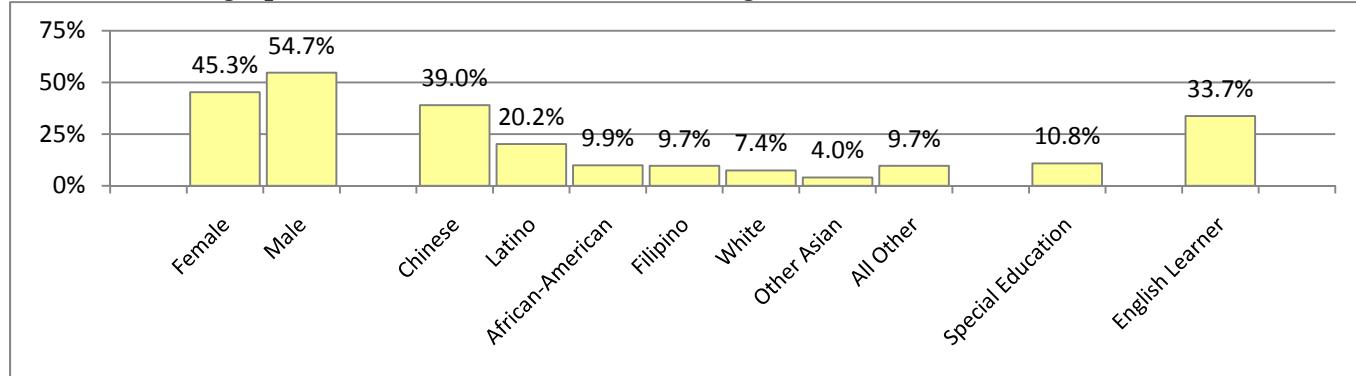
- Most students scoring Proficient or Advanced on the Summative Math or Algebra 2 California Standards Test (CST) or scoring "college-ready" or "conditionally college-ready" on the Early Assessment Program (EAP) placed at college-level on CCSF's math placement test;
- Taking and passing higher-level math courses in high school resulted in better performance on the CCSF math placement test, however just 17% of students who passed an Algebra 2 course and 49% of students who passed a Trigonometry or Pre-Calculus course at SFUSD placed into college-level math at CCSF;
- Students were more likely to place college-ready if they had consistently higher grades through all their math courses, including Algebra 1 and Geometry, and if they took additional math through 12<sup>th</sup> grade;
- The relationship between course grades and college-placement varied significantly among high schools.

### Characteristics of SFUSD Graduates Attending CCSF

This analysis followed six cohorts of students who were enrolled as first-time SFUSD 9<sup>th</sup> graders in any school year from 2000-01 through 2005-06. Students were included in the analysis if they graduated from SFUSD in four years, attended CCSF within three

years after graduating (from the 2004-05 through 2009-10 school years), and took CCSF's math placement test (described below), resulting in a cohort of 5,689 students.<sup>1</sup> Approximately 60% of CCSF attendees were Chinese or Latino and one-third of all students were classified as English learners at the time of their high school graduation (Exhibit 1).

### Exhibit 1. Demographics for SFUSD Graduates Entering CCSF



Note: Table includes all 5,689 four-year SFUSD graduates who entered CCSF from 2004-05 through 2009-10.

### CCSF Math Placement Test

Many high school students graduate and enter college unprepared for college-level work. A national study estimated that a third of students entering two-year public institutions required at least one remedial math course (National Center for Educational Statistics, 2003). Others have argued that the numbers are likely much higher; individual community colleges have reported math remediation rates as high as 95% (Venezia, Kirst, & Antonio, 2003). These reports are challenged by the lack of a consistent definition of "college-level" math (or English) especially because community colleges use different placement tests.

CCSF students take the ACCUPLACER®, usually during the spring semester of their senior year or the summer after high school graduation, to determine their appropriate math placement.<sup>2</sup> Approximately 92% of SFUSD students we followed took the placement test and the remaining students either did not take the test or were able to waive the requirement.<sup>3</sup> Test results are used to assign students to one of four placement categories: college-level, upper pre-collegiate (i.e. Intermediate Algebra), lower pre-collegiate (i.e. Elementary Algebra), or basic (i.e. Arithmetic).<sup>4</sup> Exhibit 2 shows that 27% of SFUSD's four-year graduates placed at college level in 2009-10, compared to 21% in 2004-05. The percentage of four-year graduates placing at the basic level decreased from 36% to 27% over the same time period.

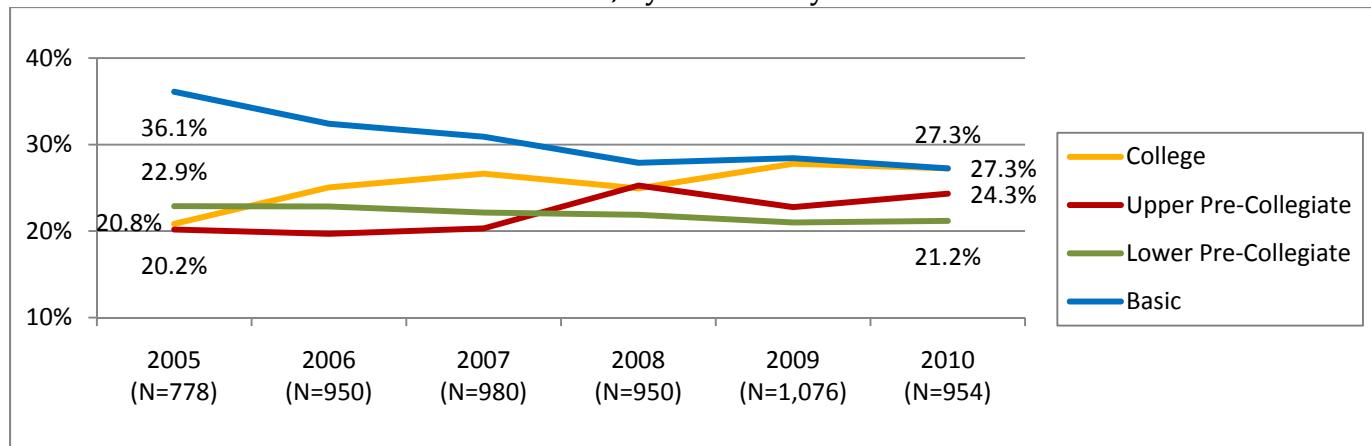
<sup>1</sup> This analysis focuses on four-year high school graduates but we believe the findings should hold for other students as well. We briefly analyzed students who left SFUSD before graduating or took more than four years to graduate from SFUSD in the appendix. Students who entered SFUSD after 9<sup>th</sup> grade were not explicitly studied.

<sup>2</sup> The two most commonly used college-placement tests in the U.S. are the ACCUPLACER®, developed by the College Board, and the COMPASS®, developed by ACT Inc. (Hughes & Scott-Clayton, 2011).

<sup>3</sup> Students may be excused from taking the math placement test by scoring sufficiently high marks on the SAT, ACT, or GRE, or passing an appropriate AP test or math course taken at another college. We did not have data to determine whether a student waived the requirement or did not take the test. Students who do not take the placement test are limited to nine units and cannot take any courses with an English or math prerequisite.

<sup>4</sup> See appendix for more detailed course descriptions.

## Exhibit 2. CCSF Math Placement Test Results, by CCSF Entry Year



## The Relationship Between SFUSD CST Performance and CCSF Math Placement

High school students take their final CST exam in 11<sup>th</sup> grade and may take one of seven different math tests, listed in Exhibit 3, depending on their level of math preparedness at the time. Students are then assigned a proficiency level from 1 (Far Below Basic) through 5 (Advanced) based on their results. Exhibit 3 shows the percentage of students who placed college-ready at CCSF, disaggregated by the specific CST test taken and student proficiency level. Almost all students who tested Proficient (4) in Algebra II or Proficient or Advanced (4 or 5) in Summative Math also placed college-ready at CCSF. In addition, over three-fourths of students testing Proficient (4) in Algebra II or Basic (3) in Summative Math tested college-ready. These data show a threshold at which significant numbers of SFUSD students exhibit college-level preparedness. However, 11<sup>th</sup> grade CST results do not account for math courses taken in 12<sup>th</sup> grade, which may influence students' CCSF placement test results. We test this assumption later in the brief.

## Exhibit 3. Percent of Students Placing College-Ready on CCSF's Math Placement Test, by CST Math Test Type and Proficiency Level in 11<sup>th</sup> Grade

CST Test Taken in 11 <sup>th</sup> Grade	11 <sup>th</sup> Grade CST Proficiency Level				
	Far Below Basic	Below Basic	Basic	Proficient	Advanced
Summative High School Math	6.1%	41.0%	76.1%	98.8%	96.6%
Algebra 2	4.7%	16.5%	55.2%	83.7%	97.1%
Integrated Math 3	0.8%	1.6%	22.8%	--	--
Geometry	0.8%	3.4%	23.3%	50.0%	--
Integrated Math 2	0.0%	0.0%	8.9%	--	--
Algebra 1	1.5%	1.0%	3.9%	--	--
Integrated Math 1	1.2%	2.0%	9.4%	33.3%	--

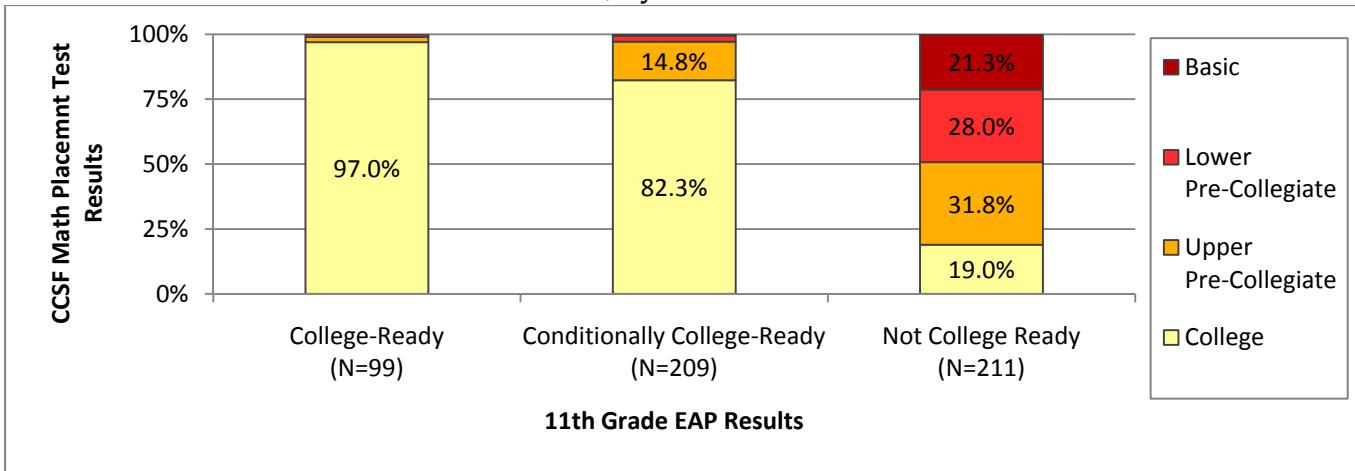
Notes: Table includes all four-year SFUSD graduates who entered CCSF from 2004-05 through 2009-10. "--" indicates that the cell has less than 20 observations.

## The Relationship Between SFUSD EAP Performance and CCSF Math Placement

Students who take the Summative Math or Algebra II CST test in 11<sup>th</sup> grade may concurrently take the Early Assessment Program (EAP) math test. The EAP, developed by the California State University (CSU) system to help high school students measure their college-readiness in advance of college math and English placement tests, was first utilized by SFUSD in the 2006-07 school year. It consists of 15 multiple choice questions appended to the CST. The results from these additional questions are combined with the CST results to create an aggregate score that informs students if they are “college-ready,” “conditionally college-ready,” or “not college ready.” Students who score “conditionally college-ready” are advised by the CSU system to take an additional math course in 12<sup>th</sup> grade to further their college preparation. Although the EAP is an optional test, SFUSD strongly encourages students to take it.

Results from the EAP show a strong relationship to college-readiness at CCSF, with students identified by the EAP as “college-ready” and “conditionally college-ready” placing college-level on the CCSF placement test 97% and 82% of the time, respectively (Exhibit 4). However, very few students met this criteria; just 308 SFUSD students who attended CCSF, or approximately 15% of incoming students, achieved an EAP level of “college-ready” or “conditionally college-ready.” Similar to the CST, EAP results are from 11<sup>th</sup> grade and may be influenced by continued student development through 12<sup>th</sup> grade.

**Exhibit 4. CCSF Math Placement Test Results, by 11<sup>th</sup> Grade EAP Results**



Note: EAP results are for 11<sup>th</sup> grade students enrolled in SFUSD during the 2006-07 or 2007-08 school years.

## The Relationship Between SFUSD Course Performance and CCSF Math Placement

Given the variety of math courses offered across SFUSD high schools, we organized courses into one of five categories: (1) AP Math (including AP Calculus and AP Statistics), (2) Pre-calculus (including Pre-Calculus, Trigonometry and Math Analysis), (3) Algebra II, (4) Geometry, and (5) Algebra I and lower-level courses. Over 80% of SFUSD graduates who attended CCSF took Algebra 2 or a higher-level math course prior to high school graduation (Exhibit 5).

### Exhibit 5. SFUSD Math Levels

Math Level	Top Math Course Taken	Most Common SFUSD Math Courses
AP Math	9.1%	AP Calculus, AP Statistics
Pre-Calculus	31.0%	Pre-Calculus, Trigonometry, Probability & Statistics, Integrated Math or Interactive Mathematics Program 7 & 8
Algebra 2	42.2%	Advanced Algebra 1 & 2, Integrated Math or Interactive Mathematics Program 5 & 6
Geometry	15.9%	Geometry, Integrated Math or Interactive Mathematics Program 3 & 4
Algebra 1 or lower-level	1.7%	Algebra 1 & 2, Integrated Math or Interactive Mathematics Program 1 & 2 and all other courses

Notes: Table includes all four-year SFUSD graduates who entered CCSF from 2004-05 through 2009-10.

Exhibit 6 shows that taking and passing higher-level math courses was associated with higher performance on the CCSF math placement test, but some questions remain. For instance, one might expect that students who passed Algebra II would be prepared to take a college-level course, yet only 17% of students who passed Algebra II by the end of high school tested college-ready. Even a few students who took the highest level math courses performed poorly on the CCSF placement test. Approximately 5% of students who passed AP Math and 24% of students who passed Pre-Calculus tested into lower pre-collegiate or basic math. This may be due to a number of factors, including poor underlying academic preparation, lack of alignment between what was taught in their most recent course and the test material, or simply having a bad test day.

### Exhibit 6. CCSF Math Placement Test Results by Highest Math Course Taken at SFUSD

		N	College	Upper Pre-Collegiate	Lower Pre-Collegiate	Basic
AP Math	Passed	351	85.8%	9.4%	3.4%	1.4%
	Did Not Pass	158	59.5%	28.5%	10.1%	1.9%
Pre-Calculus	Passed	1,109	48.7%	27.1%	15.5%	8.7%
	Did Not Pass	651	29.2%	29.6%	22.3%	18.9%
Algebra 2	Passed	1,291	17.2%	25.7%	25.0%	32.1%
	Did Not Pass	1,107	7.9%	24.0%	28.8%	39.3%
Geometry	Passed	533	1.7%	9.8%	24.2%	64.4%
	Did Not Pass	371	1.6%	8.9%	31.3%	58.2%
Algebra 1 or Below	Passed	76	1.3%	3.9%	9.2%	85.5%
	Did Not Pass	22	0.0%	0.0%	13.6%	86.4%

Notes: Table includes all four-year SFUSD graduates who entered CCSF from 2004-05 through 2009-10. Students with a grade of A, B, or C passed the course and students with a D or F did not pass the course.

## High School Attended and CCSF Math Placement

Further investigation shows that the relationship between CST results, course grades and CCSF math placement varied significantly among SFUSD high schools. Gaps in student performance across schools may result from inconsistent standards or different expectations, the relative effectiveness of a particular pedagogy, curricula or textbooks, differences in class size, the type of higher-level course offerings, or other school-level differences. Individual-level characteristics may also play a role in school-level performance if they are more highly concentrated in particular schools. These might include a student's test-taking skills or confidence, level of understanding of the consequences of poor placement test performance, or access to extracurricular test prep courses.

Examining thirteen high schools that had significant numbers of graduating students who attended CCSF, we found that:

- The percent of students who took Algebra 2 (as their highest math course) with a grade of A or B and who placed at the college level in math ranged from 0% at the lowest-performing school to 80% at the highest-performing school.
- The percent of Pre-Calculus students with a grade of A or B who placed at the college level in math ranged from 13% at the lowest-performing school to 95% at the highest-performing school.
- The college level math placement rate was largely the same across schools for students who received an A or B in AP Math.

Perhaps surprisingly, there were also large differences across schools in the relationship between CST results and math placement test results. This may be because CST results are from 11<sup>th</sup> grade and do not incorporate students' math performance in the last year of high school. Comparing five high schools that had significant numbers of students who scored at a high level on the CST and subsequently attended CCSF, we found that:

- For students who scored Proficient or Advanced on the Algebra 2 CST, the percent of students placing at the college level in math ranged from 97% to 63% across schools. For students who scored Basic on Algebra 2, the percent of students placing at college level ranged from 37% to 88%.
- There was almost no difference in college-placement results among high schools for students who took the Summative Math CST.

## Regression Analysis Examining Key Factors Influencing Placement Results

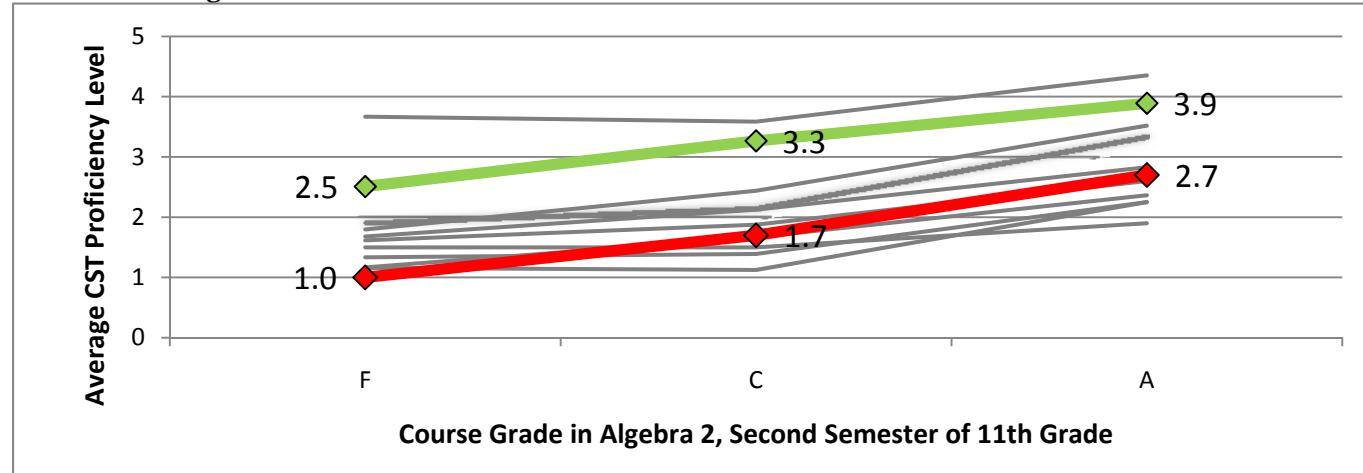
As the above makes clear, the relationship between course grades in SFUSD and student performance on the math placement test at CCSF varies significantly among high schools. We do not have access to data that would allow us to study important differences among schools, such as teaching pedagogy and class sizes, but we are able to examine some key aspects of SFUSD students' math experiences and its relationship to college placement. From the group of SFUSD graduates who subsequently attended CCSF, we focused on 2,405 students who were enrolled in Algebra 2 in the second semester of 11<sup>th</sup> grade anytime

from 2002-03 through 2007-08. In a regression framework that allows us to control for multiple factors simultaneously, we examined these students' overall math performance at SFUSD and what factors predicted whether a student placed at college-level on CCSF's math placement test.<sup>5</sup> Key findings include:

- Higher Algebra 2 course grades predicted better performance on the CCSF placement test, but earlier course grades in Geometry and Algebra 1 had additional predictive value. This indicates that performing well in higher-level math courses is not sufficient, as even students who received an A in Algebra 2 were less likely to place college-ready if they had lower performance in Geometry or Algebra 1 in previous years.
- The relationship between course grades and CST results varied significantly among SFUSD high schools. Students at schools where course grades predicted higher CST results performed better on CCSF's placement test.

Exhibit 9 displays these findings, examining the relationship between Algebra 2 course grades and CST scores at two schools: the green line identifies a high-performing school and the red line identifies a low-performing school (the remaining SFUSD high schools are in gray). In both schools, course grades are meaningful predictors of academic preparedness, as students who received an A in Algebra 2 scored, on average, higher on the Algebra 2 CST than students who received a lower grade. However, there is inconsistency across schools in the relationship between grades and CST scores. A grade of C in the school denoted by the red line produces a lower CST score than a C performance in the school denoted by the green line. This difference in the relationship between grades and CST performance levels accounted for most of the variation in school-level placement test performance at CCSF.

**Exhibit 9. Average Algebra 2 CST Proficiency Level for SFUSD High Schools, by Course Grade Received in Algebra 2**



<sup>5</sup> The appendix provides a more complete description of this group and presents full regression results.

Additional findings include:

- Students who took math through the end of 12<sup>th</sup> grade showed significantly better results on the CCSF placement test (as much as a 15 to 20 percentage point increase in the likelihood of placing college-ready). We caution that approximately 60% of the cohort took math through 12<sup>th</sup> grade so it may be that students with more aptitude for math either self-selected or were selected by school staff to continue to take math.<sup>6</sup>
- Students who waited one to two years to enter CCSF after SFUSD graduation exhibited the same performance as those who entered immediately after graduation, controlling for other characteristics.
- After controlling for high school math course performance, we did not find a relationship between CCSF placement test performance and parental education, English learner status, or special education status. Students identified as Chinese or Other Asian (excluding Filipino students) exhibited significantly higher performance on the placement test as compared to all other groups. African-American and Hispanic students exhibited slightly lower performance as compared to Whites, after controlling for math performance and other factors, but differences between these groups were not statistically significant.

## Conclusion

This analysis identified indicators of high school math performance that predicted high-levels of college-level placement at CCSF: passing an AP Calculus or Statistics course, scoring Proficient or Advanced on the Algebra 2 CST, scoring Basic, Proficient, or Advanced on the Summative Math CST, or being considered “college-ready” or “conditionally-college ready” on the EAP. CCSF began a pilot program in 2010-11 that waived the math placement test requirement for students who scored “college-ready” on the EAP math test, and these new indicators might serve as additional exemptions that allow more students to begin their postsecondary career in college-level coursework.

Of perhaps greater concern was the fact that passing Algebra 2 or even Pre-Calculus did not guarantee college-level placement based on the CCSF placement test. Further analysis showed large differences in placement test performance among high schools, and much of this difference is explained by the variation in the relationship between course grades and CST results among high schools. One immediate way in which SFUSD and CCSF staff could work together on this would be to investigate placement test results to determine which specific strands (e.g. adding fractions, geometric principles) are most problematic for incoming students.

These results highlight a key challenge: graduating from high school, even for students who completed college-level math coursework, does not necessarily indicate college-readiness in math. Students must graduate ready for college-level math so that this course does not serve as a “gatekeeper,” preventing otherwise capable students from pursuing their varied career goals. Most students who place below

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<sup>6</sup> Approximately 15% of students continued to take some math in the first semester of 12<sup>th</sup> grade but we did not see statistically significant improvements in their performance on the placement test.

college-level at a two-year institution do not ever reach a college-level math (or English) course that would allow them to graduate or transfer to a four-year institution (Bailey, Jeong, & Cho, 2010; City College of San Francisco, 2010). The Common Core State Standards Initiative, a nationally initiated and state-led effort to develop consistent standards that define the knowledge and skills students should have within their K-12 education careers, is one way that states and districts are working to align curricula to ensure that all students are prepared for a postsecondary career. Just as important as differences in curricula, research highlights the need to better understand not just what is being taught, but how it is being taught (Hiebert & Grouws, 2007; Hodara, 2011). This issue must also be addressed earlier than high school, as elementary school math results are some of the strongest predictors of students' long-term academic success (Duncan et al., 2007).

Finally, it is important to recognize how developmental pathways affect student performance. Care must be taken so that standardized tests that evaluate students at only one point in time, such as the math and English placement test for college freshmen, are effective measures and do not negatively impact student outcomes by preventing student progression through their postsecondary coursework in a timely manner. This can be done through multiple measure approaches to student placement or by accelerating developmental pathways, for example, by compressing multiple courses into one semester or allowing students to enroll in college-level courses at the same time as they complete that course's math prerequisites (Edgecombe, 2011; Hughes & Scott-Clayton, 2011). CCSF is currently discussing a number of possible approaches to altering placement test policies and developmental courses sequences in order to increase student success.

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*For more information about the study on "Math Articulation Between the San Francisco Unified School District and the City College of San Francisco," please contact Oded Gurantz at [ogurantz@stanford.edu](mailto:ogurantz@stanford.edu).*

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## Appendix

### City College of San Francisco Math Placement Test Results and Corresponding Courses:

#### Appendix Exhibit 1. CCSF Math Course Descriptions, by Placement Test Results

Placement Results	Placement Categories	Course Description
EGH	Basic	MATH E1. Basic Mathematics: Fundamental concepts and processes of arithmetic, translation of English statements to arithmetic statements, and solution of applied problems.
840	Lower Pre-Collegiate	MATH 840. Elementary Algebra: Fundamental operations on integers, rational numbers, polynomials, and algebraic expressions; linear and quadratic equations; linear inequalities; integer exponents and square roots; graphing; systems of equations; and applications.
860	Upper Pre-Collegiate	MATH 860. Intermediate Algebra: Polynomials and rational expressions; radicals and rational exponents; complex numbers; equations and inequalities; distance formula, lines, circles, parabolas; introduction to functions and graphs; introduction to exponential and logarithmic expressions; applications
90	College	MATH 90. Advanced Algebra: Geometric transformations and conic sections; real functions and their graphs; one-to-one and inverse functions; roots of polynomials; linear systems and matrices; topics in discrete mathematics.
95	College	MATH 95. Trigonometry: Circular (trigonometric) functions, identities, and equations; graphs of circular functions; arcfuctions (inverse trigonometric functions); triangles; complex numbers.
110A	College	MATH 110A. Calculus I: Limits, continuity, differentiation, applications of differentiation, and an introduction to integration.

Note: All college-level courses are CSU/UC transferable.

## Placement Test Outcomes for Alternative SFUSD Groups

Five- and Six-Year SFUSD Graduates: There were 298 students who graduated SFUSD in five or six years and attended CCSF the following year. Approximately 19% of these students had no placement test results, which was significantly higher than four-year graduates who had a 7% rate of missing the placement test. Five- and six-year graduates had generally poor placement test results: 11% tested at college-level, 14% at upper pre-collegiate, 25% at lower pre-collegiate, and 51% at the basic level.

SFUSD Non-Graduates: There were 1,743 students who were enrolled in SFUSD as 9<sup>th</sup> grade students, left SFUSD without graduating from the 2003-04 through 2008-09 school years, and enrolled at CCSF the following year. We exclude students who entered CCSF more than one year after leaving SFUSD as they may have transferred and graduated from another secondary institution in that intervening period.

Overall, approximately half of all non-graduates took no placement test at CCSF and another one-quarter tested at the basic level. Results varied by the last grade a student was enrolled in SFUSD; students who left SFUSD at a higher grade level were more likely to take a placement test than students who left early in their high school career. Upper grade students were more likely to place at college-level or upper pre-collegiate than lower grade students, even after omitting students with no placement exam, but few students tested at these high levels.

### Appendix Exhibit 2. CCSF Math Placement Results for SFUSD Non-Graduates

Last Grade Level at SFUSD	N	College	Upper Pre-Collegiate	Lower Pre-Collegiate	Basic	No Placement Test
9	202	1.0%	0.5%	9.4%	12.4%	76.7%
10	457	2.6%	5.3%	10.1%	22.3%	59.7%
11	515	4.7%	8.7%	16.7%	21.6%	48.3%
12	569	7.0%	9.1%	16.0%	34.3%	33.6%
<b>TOTAL</b>	<b>1,743</b>	<b>4.5%</b>	<b>7.0%</b>	<b>13.9%</b>	<b>24.8%</b>	<b>49.8%</b>

## Regression Analysis

Regression results used a two-level Hierarchical Linear Modeling (HLM) approach which nested students within schools. Final results focused on 12 schools with 2,405 students, ranging from 22 to 471 students per school.<sup>7</sup>

Level-1 (individual) variables included were: GPA (from 0-4) for Algebra 2, Geometry, and Algebra 1 courses, two dummy variables indicating whether a student continue taking math into first or second semester of 12<sup>th</sup> grade, dummy variables indicating whether a student entered CCSF immediately, one, or two years after graduation, dummy variables for ethnicity, gender, special education status, and final English learner status.

Level-2 (school) variables tested were: the percentage of free and reduced price lunch students and overall teacher-student staff ratios (from Dataquest), the percentage of students in various ethnic groups, the percentage of students in a school that took math through 12<sup>th</sup> grade (attempting to proxy for school-level differences in math policies or higher-level course offerings), and “CST-to-grade ratio,” a variable which measured the school-level relationship between course grades and performance on the annual California Standards Test. The “CST-to-grade ratio” was constructed in three different ways, illustrated in Appendix Exhibit 3. General results were invariant across the specifications.

### Appendix Exhibit 3. Construction of School-Level “CST-to-grade ratio” variable

Description	Formula	Individual-level Mean (St. Dev, Min, Max)
(1) Algebra 2 CST proficiency level for all students receiving a grade of “B” in Algebra 2	CST_PL	2.75 (1.10, 1, 5)
(2) Ratio of Algebra 2 CST proficiency level to course GPA, for all students who passed Algebra 2	CST_PL/CourseGPA, where Course GPA ranged from 2 to 4 (e.g. C=2)	1.03 (0.48, 0.25, 2.5)
(3) Ratio of Algebra 2 CST proficiency level to course GPA plus one, for all students who took Algebra 2	CST_PL/(CourseGPA+1), where Course GPA ranged from 0 to 4 (e.g. C=2)	1.00 (0.67, 0.2, 5)

Appendix Exhibit 4 provides estimates for three separate models. Model 1 is a one-way ANOVA with random effects; approximately 78% of the total variation is within-school and 22% is between-school. Model 2 is our final level-1 model after insignificant variables were eliminated; approximately 20% of the within-school variation is explained by the addition of these variables. Regression results rejected the usage of random slopes for all individual-level variables except Algebra 1 GPA, although even in this case there was no significant relationship found between slopes and intercepts (omitted below). Model 3

<sup>7</sup> Eleven of the twelve schools had fifty or more students. Students from Balboa High were not included as few students took the Algebra 2 CST, preventing us from calculating a value for the “CST-to-grade ratio” variable (most Balboa students in Algebra 2 took the Integrated Math 3 CST). The first cohort of 9<sup>th</sup> grade students from 2000-01 were not included as transcripts files did not include their performance in Algebra 1, which was found to be predictive of math placement. A total of 76 observations were deleted that had missing values.

includes the grand-mean centered school-level variable “CST-to-grade ratio”; approximately 80% of the between-school variance is explained by the addition of this one variable. The inclusion of this school-level variable rendered insignificant the need for random slopes for Algebra 1 GPA but we include this specification as its deletion results in little change in the model.

**Appendix Exhibit 4. Regressions Predicting College-Level Placement on CCSF Math Placement Test**

Random Effect	Model 1		Model 2		Model 3	
	Variance Component	p value	Variance Component	p value	Variance Component	p value
School Mean	0.049* (0.021)	2.29	0.049* (0.021)	2.30	0.010* (0.005)	2.04
Algebra 1 GPA slope			0.003* (0.002)	1.77	0.001 (0.001)	1.36
Level-1 effect	0.171** (0.005)	34.59	0.136** (0.004)	34.50	0.136** (0.004)	34.50
Fixed Effect	Coefficient	t ratio	Coefficient	t ratio	Coefficient	t ratio
Intercept	0.222** (0.065)	3.41	0.221** (0.065)	3.42	0.313** (0.034)	9.31
Algebra 2 GPA			0.062** (0.007)	9.26	0.062** (0.007)	9.33
Geometry GPA			0.038** (0.008)	4.76	0.038** (0.008)	4.80
Algebra 1 GPA			0.047** (0.018)	2.58	0.064** (0.014)	4.54
Final math course in the first semester of 12th grade			0.038 (0.026)	1.45	0.038 (0.026)	1.47
Final math course in the second semester of 12th grade			0.168** (0.020)	8.56	0.167** (0.020)	8.52
Asian			0.122** (0.017)	7.13	0.121** (0.017)	7.06
CST-to-grade ratio					0.775** (0.124)	6.25
CST-to-grade ratio * Algebra 2 GPA					0.082** (0.029)	2.81
CST-to-grade ratio * Algebra 1 GPA					0.147** (0.055)	2.69
-2 Res Log Likelihood	2624.0		2123.5		2111.2	
AIC (smaller is better)	2628.0		2131.5		2119.2	
Number of Observations Read	2,405		2,405		2,405	

Notes: \*\* p<=0.01, \* p<=0.05. Standard errors in parentheses. All individual-level characteristics are group-mean centered.

Models presented here used the third version of CST-to-grade ratio. Statistically insignificant interactions between the CST-to-grade ratio and other student-level variables were removed from Model 3.