

**High School Mathematics Achievement for a Cohort of Students
(2002 to 2005): Large-Scale Assessments and Math Coursework**

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I. Purpose of Report

This Report describes mathematics performance for a cohort of Pittsburgh Public School (PPS) students in grades 9, 10, and 11 across a three-year time period. It is intended to serve as a supplement to the annual *Report to the Community on Public School Progress in Pittsburgh* (A+ Schools, (2006a, 2006b, 2007).

Six indicators of mathematics performance were analyzed. The first three indicators, listed below, include scaled scores on three large-scale, standardized tests. The remaining three indicators represent mathematics coursework during the three-year span from 2002-03 to 2004-05.

- 1) TerraNova (TN) scores for 9th graders in 2002-03
- 2) New Standards (NS) scores for 10th graders in 2003-04
- 3) Pennsylvania System of School Assessment (PSSA) scores for 11th graders in 2004-05
- 4) Grade point average (GPA) for math courses
- 5) Number of unique math courses taken
- 6) Type of math course taken

The Report begins with an executive summary followed by five sections of results. First, demographic characteristics of the cohort are described and compared to characteristics of non-cohort PPS students. The second section of results presents math performance on the three large-scale assessments for all cohort students and by subgroups of gender, ethnicity, and socioeconomic status. The third section describes math coursework taken by the cohort and their overall GPA in math. The fourth section shows relationships among assessment and coursework indicators. Finally, the last section examines how well the TN and NS assessments and the math coursework indicators are able to predict PSSA performance in 11th grade.

II. Executive Summary

Over the past several years, average scores for Pittsburgh Public School (PPS) students on the 11th grade PSSA have been below the state average. The purpose of this report is to obtain a broader picture of high school students' math achievement. How do students perform on other indicators of math achievement? What is the nature of the relationships among these indicators? To this end, a cohort of students who attended the district's high schools from 2002-03 in 9th grade to 2004-05 in 11th grade was identified. Students' scaled scores on three large-scale assessments (PSSA, TerraNova (TN), and New Standards Reference Examination (NS)) as well as students' mathematics grade point average, number of math courses taken, and type of math course were examined.

A. Previous Research on Math Achievement and Coursework

Statewide studies on the PSSA were conducted to determine how well scores correlate with other large-scale assessments and with student's self-reported grade point average in math (Thacker, Dickinson, & Koger, 2004; Koger, Thacker, & Dickinson, 2004). These studies showed that students' PSSA performance was strongly related to their performance on the TN and the SAT. The relationship between high school GPA in math and the PSSA was also high.

Beyond Pennsylvania, the mathematics education community and other testing programs are also studying relationships between coursework and achievement in order to identify courses that are critical for student's future success (e.g., ACT, 2004; Ma & Wilkins, 2007). Ma & Wilkins (2007) found that "regular" math courses had the smallest impact on growth in math achievement, whereas "advanced" math courses had the largest impact. Several studies published by ACT investigated the relationship between high school math coursework and future success in college. "Not only is taking the *right number* of courses important, but taking the *right kind* of courses is critical to student readiness for college-level work" (ACT, 2004, p. v).

One strength of the analysis in this Report on PPS high school students is that, unlike many other studies that incorporate high school grades, the math coursework indicators were not self-report data. The actual grades received by students, the number of courses taken, and the type of courses were analyzed. Results from the Report are briefly summarized below.

B. Description of Cohort

A total of 1,298 students were in the cohort. This represents all students who were enrolled in PPS high schools from 9th grade in 2002-03 to 11th grade in 2004-05 and who took the TN, NS, and PSSA in the respective years. The demographics of cohort students versus non-cohort students were compared. The cohort had significantly higher percentages of female students, white students, and students not eligible for free/reduced lunch than the non-cohort. The cohort had a significantly lower percentage of students receiving special education services. Not surprisingly, the cohort also had a higher percentage of stable attenders than the non-cohort. Stable attenders are identified by the district as students who remain in the same school throughout the year and attend at least 95% of the time.

C. Math Performance on Large-Scale Assessments

In comparison to non-cohort test-takers, the cohort had significantly higher mean scores on the TN, NS, and PSSA as well as a significantly higher math GPA. Performance across demographic subgroups was also examined within the cohort. With respect to gender, there were no significant differences between male and female scores on each of the three assessments.

Although white students had significantly higher achievement on the assessments than black students, interesting results were found when examining the simultaneous impact of ethnicity and socioeconomic status (SES). The pattern of scores for free/reduced lunch versus regular lunch students was the same for both ethnicities. In other words, there was an achievement gap for SES in the white subgroup as well as the black subgroup. For example, in 9th grade the gap in TN scores between the two SES groups was 24 points for white students and 17 points for black students. Similar results occurred for the NS assessment in 10th grade and the PSSA in 11th grade.

D. Math Coursework

On average, cohort students took 3 math courses from 2002-03 to 2004-05. The variation in the number of courses taken was quite small, most likely because all PPS students are required to take a set of core courses that included algebra 1, geometry, and algebra 2. There were no significant differences in the number of math courses between black and white students or between free/reduced and regular lunch students.

The type of math courses taken by cohort students was also examined. Overall, 64% of students took only the core courses (algebra 1, geometry, and algebra 2), whereas 36% took at least one math course beyond the core. These advanced courses included elementary functions, calculus, statistics, and advanced topics. Percentages were nearly identical for males and females. Although significant differences occurred between the black and white subgroups, a gap between the two SES levels was prevalent for both ethnicities. Within the black subgroup, a higher percentage of regular lunch (36%) than free/reduced lunch students (15%) took advanced courses, a gap of 21 percentage points. Within the white subgroup, the percentages were 51% and 24%, respectively, a gap of 27 percentage points.

The average GPA in math for the cohort was 2.38 (sd=.91), significantly lower than the average total GPA of 2.72 (sd=.76) for the cohort. Females had a significantly higher math GPA than males, although the magnitude of the difference was rather small. When comparing ethnicities, the white subgroup had a significantly higher GPA math than the black subgroup. However, once again, when incorporating SES, a gap between free/reduced versus regular lunch students was found for both ethnicities (.33 for white students and .14 for black students.)

E. Relationships Among Math Achievement Indicators

Nearly all math achievement indicators were strongly related to PSSA scores. The TN and NS assessments correlated most highly with PSSA ($r = .780$ and $r = .859$, respectively). Students who score high on the TN tend to score high on the PSSA. The same can be said for the relationship between the NS and the PSSA.

Two math coursework indicators, course type and GPA math, also had strong relationships with the PSSA ($r = .557$ and $r = .672$, respectively). Students who take advanced math courses tend to score higher on the PSSA. Students with high GPA in math courses tend to have high PSSA math scores. The only indicator not related to PSSA was the number of courses taken.

F. Predicting PSSA Performance

Analyses were conducted to determine how accurately 11th grade PSSA performance can be predicted by scores on prior assessments, math GPA, type of math courses taken, and number of math courses. After removing the influence of ethnicity and SES, which accounted for 27% of the variance in PSSA scores, the set of math achievement indicators accounted for an additional 52% (for a total of 79% explained variance in PSSA scores). A comparison of students' actual PSSA scores to their predicted PSSA scores showed that the differences (i.e., residuals) were extremely small. Generally speaking, if you know students' test scores in previous years, the type of math classes taken and math grades, a good estimate of their performance on the PSSA is likely to be obtained.

Both TN and NS are significant predictors of PSSA. Math GPA and type of course are also significant predictors of PSSA, but the number of courses taken is not. Finally, an interesting result shows that when the TN and NS are not used as predictors, the two math coursework indicators are still able to explain a relatively large portion of variance in PSSA scores. That is, they explain an additional 34% beyond the 27% accounted for by ethnicity and SES (for a total of 61% of variance in PSSA scores.)

G. Concluding Remarks

For years, measurement and testing professionals have cautioned against using only one form of assessment to determine student achievement in a content area. Yet it is still common practice in states, districts, and schools to use scores from a single test as the only criterion for making important decisions.

This report is intended to provide accessible, user-friendly data from multiple indicators of student achievement in mathematics. Demographic subgroups are compared for each indicator and the nature of relationships among indicators are described. In essence, it provides a snapshot of students' math performance in PPS high schools. In order to have a direct, positive impact in schools, the results from this research suggest the need for additional data and analyses to answer questions such as "Why are the numbers showing what they show?"

For example, there are several potential areas for further investigation of the math coursework indicators. Many variations of each core course exist, from basic to honors as well as courses offered in specific high school programs and courses offered during the summer. An examination of the curriculum and implementation of each variation would be beneficial in understanding the mathematics content that students are presented with and have an opportunity to learn.

Secondly, this cohort of students represents a portion of the total population of PPS high school students. Because one purpose of the study was to investigate relationships among indicators over time, it was necessary to identify students who were in PPS schools for all three years and

who took the tests. Although the report compares math assessment results for cohort versus non-cohort students, it would be valuable to examine math coursework results for the non-cohort students at each grade level, 9th through 12th.

Third, math learning at grade levels prior to high school may be studied. The middle school years are important ones in shaping students' disposition about math and providing them with the foundations of quantitative thinking, reasoning, and communication. By conducting analyses in the earlier grade levels, questions could be answered about the impact that middle-school course-taking patterns and grades have on later math achievement.

Finally, across the nation, the achievement gap between students of different ethnicities is heavily focused upon. Although it is recognized that socioeconomic status and academic achievement are related, rarely is student data presented by socioeconomic status within ethnicity. A common misconception, especially in urban areas, is that the SES variable overlaps with the ethnicity variable. In other words, many people believe that both variables produce the same grouping of students. However, this is not the case in PPS. In the cohort, 33% of the black students were in the regular lunch subgroup and 23% of the white students were in the free/reduced lunch subgroup. Analyses in this report compared results for the four subgroups, and interesting patterns were uncovered. For each achievement indicator, there was an SES achievement gap for both black and white students. Further study of these disaggregated groups needs to occur.

III. Description of Cohort

A. Cohort Size

The first step in the analysis was to identify the cohort of students who were in PPS high schools during the entire three-year span (2002-03, 2003-04, and 2004-05) and who also took all three assessments (TN, NS, and PSSA). Table 1 shows the total number of students in each grade, the number of students who took each assessment, and the final number of cohort students.

Table 1. Cohort size compared to all students in each grade and students who took each assessment.

	9 th grade 2002-03	10 th grade 2003-04	11 th grade 2004-05
All students	3221	2543	2057
Students who took the math assessment	2320 ^a	1727 ^b	1846 ^c
Students who took the math assessment and are in the cohort	1298	1298	1298

^aNumber of students taking the TN

^bNumber of students taking the NS

^cNumber of students taking the PSSA

- As shown in the first row of the table, the total number of PPS students decreased across the three years/grade levels (from 3221 9th grade students in 2002-03 to 2057 11th grade students in 2004-05).
- The second row in the table shows the total number of students who had scores on each math test. The state test (PSSA) had the highest percentage of students with scores.
- The third row indicates the final cohort size of 1298 students. This represents all students who remained in PPS high schools from 9th to 11th grade and who took the TN, NS, and the PSSA. It should be noted that movement within schools in the district was not examined in this particular report.

B. Cohort Demographics

Cohort students were compared to all non-cohort students in each grade. Gender, ethnicity, socioeconomic status (SES), mobility/attendance, and special education were examined. The 9th grade comparison is shown in Table 2. Student percentages for each demographic subgroup are given along with results from a chi-square analysis to determine statistical significance. The cohort was significantly different from the non-cohort students for each demographic examined. Comparisons for the 10th and 11th grades were similar to the 9th grade results and are included in Appendix A.

Table 2. Comparison of Cohort to Non-Cohort 9th Grade Students in 2002-03.

	Cohort students (n=1298)	Non-cohort 9 th grade students n=(1923)	χ^2	<i>p</i>
Gender				
males	42.1%	52.8%	35.98	<.001
females	57.9%	47.2%		
Ethnicity				
black	42.1%	66.7%	80.77	<.001
white	54.8%	29.6%		
other	3.2%	3.7%		
SES				
free/reduced	42.2%	66.0%	162.51	<.001
regular	57.8%	34.0%		
Mobility/Attendance ¹				
SA	74.4%	20.6%	706.97	<.001
SNA	20.4%	51.0%		
MA	2.8%	4.9%		
MNA	2.4%	23.5%		
Special Education				
no	96.9%	86.6%	98.55	<.001
yes	3.1%	13.4%		

¹SA=stable attenders, SNA=stable nonattenders, MA=mobile attenders, MNA=mobile nonattenders.

- A smaller percentage of male students were in the cohort compared to the non-cohort.
- A smaller percentage of black students were in the cohort compared to the non-cohort.
- A smaller percentage of students eligible for free/reduced lunch were in the cohort compared to the non-cohort.

- With respect to mobility and attendance, a larger percentage of the cohort compared to the non-cohort were classified as stable attenders. This is not surprising since the nature of a cohort reflects stability and, in this case, attendance for the math tests.
- The cohort had a smaller percentage of students receiving special education services than the non-cohort.
- Another way to summarize the above comparisons is to say that the cohort had higher percentages of female students, white students, students not eligible for the lunch program, and students not receiving special education services compared to the non-cohort students. In addition, the majority of the cohort students were considered “stable attenders”.

IV. Math Achievement on Large-Scale Assessments

A. All Cohort Students

The average scaled math scores on the TN, NS, and PSSA for the cohort were compared to the average scores for non-cohort test-takers in each year. Table 3 provides the means and standard deviations for each test, results from t-tests to determine statistical significance, and effect sizes to provide an indication of the magnitude of the difference.

Table 3. Student performance on three math assessments for the cohort versus non-cohort test-takers.

	Cohort n=1298 M (SD)	Non-cohort test- takers¹ M (SD)	t	p	Effect size
TN	715.45 (46.97)	674.40 (52.17)	19.90	<.001	.83
NS	143.80 (11.10)	134.12 (11.12)	15.65	<.001	.87
PSSA	1334.92 (268.18)	1127.06 (253.74)	15.46	<.001	.79
GPA math	2.38 (.91)	1.59 (1.17)	14.10	<.001	.79

¹Sample sizes for non-cohort test takers were 1022 for TN, 429 for NS, and 548 for PSSA, and GPA math.

- For each test, the cohort had a significantly higher average math score than the non-cohort. In addition, the effect sizes were large (.79 and above), indicating that not only were the results statistically significant, the magnitude of the differences in means was substantial.
- Also, the average math GPA was significantly higher for the cohort than the non-cohort, with a large effect size.

B. Demographic Subgroups of Gender, Ethnicity, and Socioeconomic Status

This section provides the cohort’s results on each of the math tests broken down by gender (male, female), ethnicity (black, white), and SES (eligible for free/reduced lunch, not eligible). Students in the “other” ethnicity subgroup were not included because of the small number of students and variety of ethnicities. Table 4 shows the means and standard deviations for each demographic subgroup and the effect sizes (ES). Results from the statistical analysis are provided in Appendix B.

Table 4. Demographic subgroup means, standard deviations, and effect sizes for three math assessments.

	Gender			Ethnicity			SES		
	male n=532	female n=725	ES	black n=546	white n=711	ES	free/red n=530	regular n=727	ES
TN	717.35 (50.74)	712.93 (43.64)	.09	691.11 (37.34)	733.00 (45.20)	-1.00*	694.54 (41.42)	729.57 (44.97)	-.81*
NS	143.47 (11.35)	143.61 (10.84)	-.01	137.19 (7.87)	148.44 (10.65)	-1.18*	138.34 (8.48)	147.35 (11.16)	-.89*
PSSA	1345.32 (271.00)	1316.20 (260.28)	.11	1184.66 (185.95)	1439.00 (263.99)	-1.09*	1209.27 (206.13)	1415.46 (269.67)	-.84*

* Indicates that the t-test result for the comparison between subgroups was statistically significant.

- Male and female scaled scores were statistically similar for each assessment. The effect size was very small, indicating almost no difference in math performance between the two genders.
- For ethnicity, scaled scores on each assessment were significantly higher for white students than black students. The effect size was large, indicating a substantial difference in math performance between the subgroups.
- For SES, scaled scores on each assessment were significantly higher for regular lunch students than free/reduced lunch students. The effect size was large, indicating a substantial difference in math performance between the subgroups.

Differences in academic achievement, like those above, have been widely publicized in other large, urban school districts. However, student performance by SES is not typically examined within each ethnicity. A common misconception is that the ethnicity classification and SES classification of students are one and the same. This is not the case in PPS. In this cohort, there was a total of 546 black students, approximately two-thirds of them (364) were eligible for free/reduced lunch and one-third were not (182). For white students, 166 were eligible for free/reduced lunch and 545 were not.

Figure 1 shows the average mathematics achievement on the 9th grade TN for black free/reduced lunch students (685.35) versus black regular lunch students (701.93), and white free/reduced lunch students (714.63) versus white regular lunch students (739.04).

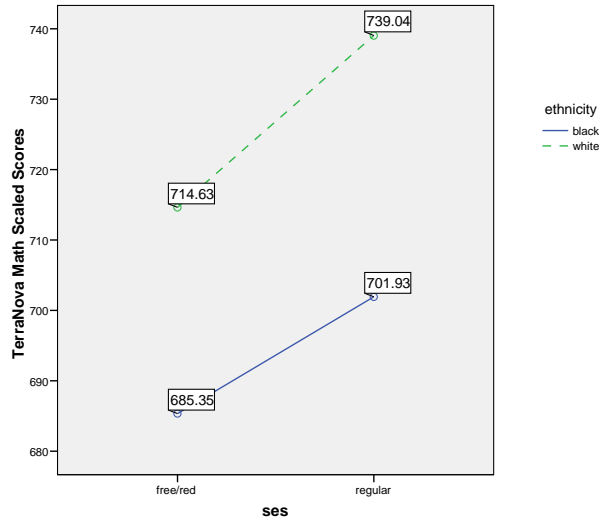


Figure 1. TerraNova (TN) math scores for ethnicity and SES subgroups.

- The difference in math scores between the two SES groups is statistically the same for each ethnicity, i.e., the lines connecting the two average scores for each ethnicity are statistically parallel.
- In other words, the gap in achievement between the free/reduced lunch group and the regular lunch group is the same for black students as it is for white students.

Figure 2 shows a similar result for the PSSA math scores. The mean mathematics performance on the 11th grade state test was 1157.94 for black free/reduced lunch students versus 1239.50 for black regular lunch students, and 1322.63 for white free/reduced lunch students versus 1476.21 for white regular lunch students.

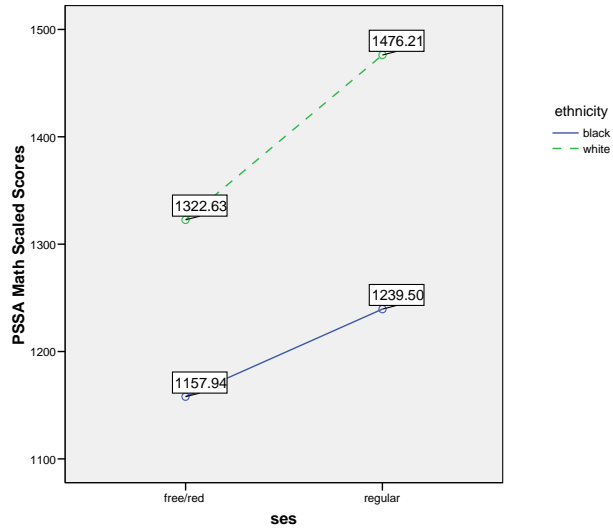


Figure 2. PSSA math scores for ethnicity and SES subgroups.

- The lines show that the gap in math achievement between free/reduced and regular lunch students is about the same for black students as it is for white students.

V. Math Coursework

A. Number of Math Courses

The average number of math courses taken by the cohort students from 9th to 11th grade was 3.08. There was only a small amount of variation across students ($sd = .35$), possibly because of the requirement that all students take a core set of courses that includes algebra 1, geometry, and algebra 2. The following is a brief description of the results. The complete set of means, standard deviations, and statistical tests are in Appendix C.

- There were no significant difference in the number of math courses taken by black students versus white students.
- There were no significant difference in the number of math courses taken by free/reduced lunch versus regular students.
- Males, on average, took significantly more math courses than females, however the magnitude of the difference between genders was quite small (3.11 courses for males versus 3.06 courses for females).

B. Math GPA

The average GPA for math courses taken by cohort students from 9th through 11th grades was 2.38 ($sd = .91$). As a point of comparison, the average GPA for all academic courses was also calculated and found to be significantly higher (2.72, $sd=.76$) than the GPA for math. Table 5 shows the means and standard deviations for each demographic subgroup and the effect sizes (ES). Results from statistical analyses are in Appendix C.

Table 5. Demographic subgroup means, standard deviations, and effect sizes for GPA total and GPA math.

	Gender			Ethnicity			SES		
	male n=532	female n=725	ES	black n=546	white n=711	ES	free/red n=530	regular n=727	ES
GPA Total	2.58 (.77)	2.79 (.73)	-.28	2.32 (.68)	3.00 (.67)	-1.01	2.40 (.71)	2.93 (.71)	-.75
GPA Math	2.27 (.91)	2.42 (.90)	-.17	1.98 (.82)	2.65 (.87)	-.79	2.08 (.87)	2.56 (.88)	-.55

Note: ES is Cohen's effect size (d).

- For gender, females had a significantly higher average GPA math and GPA total than males. But the magnitude of the differences between genders was small.

- For ethnicity, the average GPA math and GPA total were significantly higher for white students than black students. Both effect sizes were large, but the gap between ethnicities was larger for GPA total than GPA math.
- For SES, the average GPA math and GPA total were significantly higher for regular lunch students than free/reduced lunch students. The effect size was large for GPA total and moderate for GPA math, indicating that the gap between SES groups was more substantial for GPA total than it was for GPA math.
- For SES within ethnicity, the gap in GPA math between free/reduced lunch students and regular students was the same for the black subgroup as it was for the white subgroup.

C. Type of Math Courses

Of the cohort students, 64% took only the core courses in mathematics (algebra 1, geometry, and algebra 2), whereas 36% of students took at least one math course beyond the core. These advanced courses included elementary functions, calculus, statistics, and advanced topics. Table 6 displays the percentages of students taking core only or core plus advanced courses by gender, ethnicity, and SES.

Table 6. Core math versus advanced math courses by demographic subgroups.

	Gender		Ethnicity		SES	
	male n=532	female n=725	black n=546	white 711	free/red n=530	regular n=727
Core Courses	65.4%	65.1%	78.0%	55.4%	82.3%	52.8%
Advanced Courses	34.6%	34.9%	22.0%	44.6%	17.7%	47.2%
χ^2	.013		69.60		117.18	
p	.909		<.001		<.001	
r	.003		.235		.305	

- The percentage of males taking advanced math courses is nearly identical to the percentage of females taking these courses.
- For ethnicity, a higher percentage of white students than black students took advanced courses. The result was statistically significant.
- For SES, a higher percentage of regular lunch students than free/reduced lunch students took advanced courses. The result was statistically significant.
- There was a stronger relationship between SES and taking advanced courses ($r = .305$) than there was for ethnicity and taking advanced courses ($r = .235$). In other words, SES had a slightly higher relationship with type of math courses than did ethnicity.

Mathematics courses were also examined by comparing SES subgroups within each ethnicity. Table 7 shows the percentages of students taking only core courses and students taking core and advanced courses.

Table 7. Core math versus advanced math courses by ethnicity and SES.

	black free/red n=364	black regular n=182	white free/red n=166	white regular n=545
Core Courses	84.9%	64.3%	76.5%	49.0%
Advanced Courses	15.1%	35.7%	23.5%	51.0%
χ^2	30.040		38.991	
p	<.001		<.001	
r	.235		.234	

- The pattern of results was similar for two ethnicities.
- Within the black subgroup, a higher percentage of regular lunch students took advanced courses compared to free/reduced lunch students.
- Within the white subgroup, a higher percentage of regular lunch students took advanced courses compared to free/reduced lunch students.
- The relationship between taking advanced courses and SES was the same for both ethnicities (.235 and .234).

D. Further Analyses of Type of Math Course

Table 8 shows the percentages of cohort students who took each type of math course across all grades (values in the first column) and within each grade (values in the remaining columns). Algebra 1, algebra 2, and geometry are core courses.

Table 8. Percentages of students taking each type of math course.

	Across all 3 years	9th grade 2002-03	10th grade 2003-04	11th grade 2004-05
General math	1.5%	0.8%	1.2%	1.6%
Algebra 1	62.6%	61.7%	5.8%	2.1%
Algebra 2	88.9%	7.9%	29.2%	54.7%
Geometry	93.6%	28.8%	63.1%	8.6%
Advanced	35.8%	0.1%	4.2%	35.8%

Note: Percentages within the grade levels may not total to 100% because some students took multiple math courses.

Across three years (9th through 11th grades)

- Approximately 94% of students in the cohort took geometry at some point during their 9th, 10th, and 11th grade years.
- Smaller percentages of students in the cohort took algebra 2 (89%) and algebra 1 (63%) during the three years. There are two possible explanations for these lower values. One is that some students may have taken these courses prior to high school, for example in 7th or 8th grade. A second possibility is that students may have taken the courses in 12th grade which was not included in this analysis.
- Approximately 36% of the cohort took at least one advanced course from 9th to 11th grade. Courses in the advanced category were not further divided because of the wide variety of courses offered and the small number of students in each of them. The two most common were elementary functions and calculus.

By grade level

- The majority of 9th graders took algebra 1 (62%). Geometry was the next largest percentage (29%).
- The majority of 10th graders took geometry (63%). Algebra 2 was the next largest percentage (29%).
- The majority of 11th graders took algebra 2 (55%). Advanced courses were the next largest percentage (36%).
- It should also be noted that some students took courses intended to prepare them for the SAT or the PSSA. These courses were not included in the calculation of the GPA for math. One-third of the students took a PSSA prep course in 11th grade and 6% of the students took an SAT prep course in 10th or 11th grade.

E. Further Analysis of GPA Math

As mentioned earlier, the overall GPA math was 2.38. GPA math was also calculated separately for students who took core courses and students who took core plus advanced courses.

- The average GPA math for students taking core and advanced courses was 2.87 (sd=.76). The average GPA math for students who took only core courses was 2.10 (sd=.88). The difference in means between the two groups was significant.

Table 9 further disaggregates the GPA math by course type and grade level. There are no GPAs shown for 9th and 10th grade advanced courses because of the small number of students who took these courses in the early grades.

Table 9. Mean GPA math by course and grade level.

	9th grade	10th grade	11th grade
	2002-03	2003-04	2004-05
General math	2.60	2.80	2.28
Algebra 1	2.11	1.76	1.65
Algebra 2	3.36	2.75	2.02
Geometry	2.78	2.21	1.43
Advanced	----	----	2.82

- For the core courses in 9th grade, algebra 2 had the highest GPA, algebra 1 had the lowest.
- For the core courses in 10th grade, algebra 2 had the highest GPA, algebra 1 had the lowest.
- For the core courses in 11th grade, algebra 2 had the highest GPA, algebra 1 and geometry had similar mean GPAs.
- For each core course, the average GPA decreased from 9th to 10th grade and again from 10th to 11th grade within each of the core courses.
- In 11th grade, the highest GPA was in the advanced courses.

VI. Relationships Between Math Assessments and Math Coursework

A. All Cohort Students

Correlations between the three large-scale assessments and the three math coursework indicators were calculated. A portion of the results are shown in Table 10. (See Appendix D for the complete correlation matrix).

Table 10. Correlations between math coursework and assessments.

	TN	NS	PSSA	Course total	Course type
GPA Math	.524*	.662*	.672*	-.111*	.403*
Course Total	-.032	-.057	-.024	---	.102*
Course Type	.522*	.612*	.557*	---	---

N=1298

*p<.001

- GPA math is significantly related to assessment scores. The strongest relationship is between GPA math and PSSA scores. Students with high GPAs in math courses tend to have high PSSA math scores.
- The type of math course is significantly related to assessment scores. Students who take advanced math courses tend to score higher on the PSSA.
- GPA math and type of math course are significantly related. Students who take advanced courses tend to receive higher grades in math.
- The number of math courses taken is not significantly related to assessment scores. One reason may be the lack of variation in the total number of math courses taken by students.

B. Relationships Within Demographic Subgroups

Separate correlations were calculated for each gender and the four subgroups of ethnicity and SES to determine if the strength of relationships varied across demographic subgroups. Table 11 shows a portion of the results. The first two columns of numbers represent the correlations for males and females. The last four columns represent the correlations for each ethnicity/SES subgroups. (See Appendix E for the complete correlation matrices.)

Table 11. Correlation coefficients for math coursework and PSSA by demographic subgroups.

	male n=546	female n=752	black free/red n=364	black regular n=182	white free/red n=166	white regular n=545
PSSA/GPA Math	.668*	.689*	.579*	.617*	.513*	.633*
PSSA/Course Type	.617*	.513*	.298*	.412*	.400*	.587*
GPA math/Course Type	.433*	.382*	.263*	.332*	.121	.401*

* p<.001

Gender

- The relationship between PSSA and GPA math was the same for male students and female students.
- However, the relationship between PSSA and course type was different for males (.617) compared to females (.513). There was a stronger relationship between taking advanced courses and scoring high on the PSSA for males.
- The relationship between GPA math and course type was the same for male students and female students.

Comparing SES groups within ethnicity

- For the black subgroup (middle two columns of the table), relationships were stronger for regular lunch students compared to free/reduced lunch students, but the differences were *not significant*. For example, the relationship between GPA math and course type was .332 for regular lunch students and .263 for free/reduced lunch students.
- For the white subgroup (last two columns of the table), relationships were stronger for regular lunch students compared to free/reduced lunch students, and the differences were *significant*. For example, the relationship between GPA math and course type was .401 for regular students but only .121 for free/reduced lunch students.

Comparing ethnicities within SES

- For free/reduced lunch subgroups, the relationships were the same for black students and white students. For example, the relationship between PSSA and GPA math was .579 for black free/reduced lunch students and .513 for white free/reduced lunch students.
- For regular lunch students, there were no significant differences in the PSSA/GPA math relationship for black students (.617) and white students (.633).

- Also for the regular lunch students, there were no significant differences in the GPA math/course type relationship for black students (.332) and white students (.401).
- However, for PSSA/course type, the relationship was significantly stronger for white regular lunch students (.587) compared to black regular lunch students (.412). This means that the association between taking advanced courses and scoring high on the PSSA was higher for white regular lunch students than black regular lunch students.

VII. Predicting PSSA Math Performance

How well can scores on prior math assessments and math coursework predict students' math scores on the 11th grade PSSA? This question was answered by running a series of regression analyses.

A. Assessments and Math Coursework

The first regression analysis examined a model that included two demographic variables (ethnicity and SES) and five mathematics achievement indicators (TN, NS, GPA math, course total, and course type). Results showed that:

- Ethnicity and SES accounted for 27% of the variance in PSSA scores.
- Over and above that, however, the five math achievement indicators accounted for an additional 52% of the variance in PSSA scores.
- Each assessment indicator (TN and NS) and math coursework indicators (GPA math, course total, and course type) were significant predictors of PSSA.
- The entire set of 7 predictors accounted for 79% of the total variation in students' actual PSSA scaled scores.
- The average differences between students actual PSSA scores and their predicted scores were quite small for the four demographic subgroups. The unstandardized residuals ranged from .74 for the white, regular lunch subgroup to -2.41 for the white, free/reduced lunch subgroup.

The next two regression analyses examined the influence of the assessment indicators separately from the math coursework indicators.

B. Assessments Only

This regression model included the two demographic variables and the two assessment indicators (TN and NS), but not the coursework indicators. Results showed that:

- Over and above the 27% of variance in PSSA scores due to the demographic variables, the TN and NS assessments accounted for an additional 50% of the variance.
- Both assessments were significant predictors of PSSA.
- The set of two demographic and two assessment indicators accounted for 77% of the total variation in students' actual PSSA scaled scores. This was nearly the same amount as the previous analysis which included math coursework.
- The average differences between students actual and predicted scores on the PSSA were small. Residuals ranged from .85 for white, regular lunch to -2.79 for white, free/reduced lunch subgroups.

C. Math Coursework Only

This regression model included the two demographic variables and the three math coursework indicators (GPA math, course total, course type), but not the assessment indicators. Results showed that:

- Over and above the 27% of variance in PSSA scores due to the demographic variables, the set of three coursework indicators accounted for an additional 34% of the variance.
- GPA math and course type were significant predictors of PSSA. Course total was not a significant predictor of PSSA.
- The set of two demographic and two assessment indicators accounted for 61% of the total variation in students' actual PSSA scaled scores. Although lower than the result for the assessment indicators, it still represents a large portion of PSSA variation and it is statistically significant.
- The average difference between students' actual and predicted PSSA scores was slightly larger than for the previous two analysis, but the unstandardized residuals are still somewhat small. They ranged from 3.83 for white, regular lunch to -12.56 for white free/reduced lunch subgroups.

VIII. References

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Appendix A
Comparison of Cohort to Non-Cohort Students
in 10th Grade (2003-04) and 11th Grade (2004-05)

10th grade students (2003-04)

	Cohort students (<i>n</i> =1298)	Non-cohort 10 th grade students <i>n</i> =(1245)	χ^2	<i>p</i>
Gender				
males	42.0%	52.9%	30.07	<.001
females	58.0%	47.1%		
Ethnicity				
black	42.0%	66.2%	14.75	<.001
white	54.8%	30.2%		
other	3.2%	3.6%		
SES				
free/reduced	41.4%	63.1%	110.77	<.001
regular	58.6%	36.9%		
Mobility/Attendance ¹				
SA	69.4%	19.0%	681.84	<.001
SNA	20.9%	33.0%		
MA	5.4%	15.5%		
MNA	4.3%	32.5%		
Special Education				
no	97.1%	85.3%	110.92	<.001
yes	2.9%	14.7%		

¹SA=stable attenders, SNA=stable nonattenders, MA=mobile attenders, MNA=mobile nonattenders.

Appendix A (cont.)

11th grade students (2004-05)

	Cohort students (<i>n</i> =1298)	Non-cohort 11 th grade students <i>n</i> =(759)	χ^2	<i>p</i>
Gender				
males	42.0%	51.5%	17.52	<.001
females	58.0%	48.5%		
Ethnicity				
black	42.0%	65.3%	75.79	<.001
white	54.8%	30.6%		
other	3.2%	4.1%		
SES				
free/reduced	38.7%	61.1%	81.37	<.001
regular	61.3%	38.9%		
Mobility/Attendance ¹				
SA	65.2%	22.9%	92.14	<.001
SNA	23.6%	28.1%		
MA	5.9%	15.9%		
MNA	5.4%	33.1%		
Special Education				
no	97.1%	77.9	195.96	<.001
yes	2.9%	22.1%		

¹SA=stable attenders, SNA=stable nonattenders, MA=mobile attenders, MNA=mobile nonattenders.

Appendix B

Results from Factorial Analyses of Variance for the Math Assessment Data

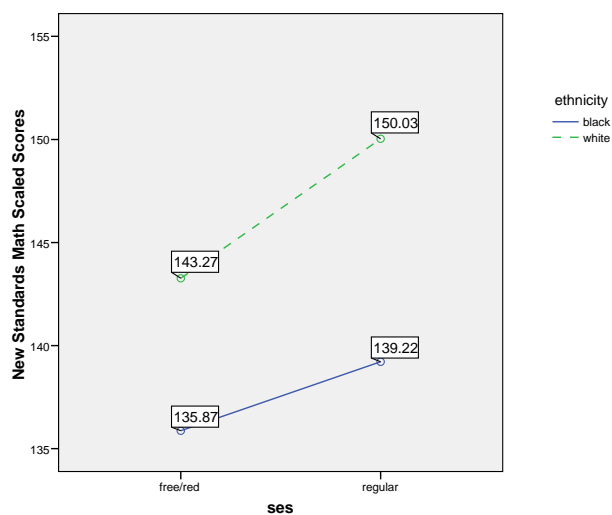
To determine which of the differences in subgroup means were statistically significant, three-factor ANOVAs were conducted. The first three rows in the table below present the results for the main effects of gender, ethnicity, and socioeconomic status on the three assessments (TN, NS, and PSSA). Consistent with the group means and effect sizes presented in Table 3 of this report, there were no significant differences in math scaled scores for the two genders, whereas the two ethnicities and the two lunch groups did differ significantly in their mean scores. The remaining four rows show results for the two-way and three-way interaction effects. None were significant with the exception of the interaction between ethnicity and SES for the NS. The plot of means for this result is shown below the table. There was a significantly larger gap in NS scores between free/reduced lunch versus regular lunch students in the white subgroup than the black subgroup.

ANOVA results for math assessments.

	TN			NS			PSSA		
	F	p		F	p		F	p	
gender	.02	.881		3.59	.058		.32	.572	
ethnicity	158.04	<.001	B < W	233.44	<.001	B < W	187.56	<.001	B < W
ses	60.28	<.001	F < R	72.02	<.001	F < R	64.36	<.001	F < R
G x E	.77	.382		.57	.450		.07	.799	
G x S	.28	.597		.94	.332		.38	.538	
E x S	2.19	.139		8.22	.004	*	6.04	.014	
G x E x S	1.85	.174		.19	.661		.23	.630	

Note: $\alpha < .01$ was used to determine significance. The third column for each variable indicates which direction the means differed. B=black, W=white, F=free/reduced lunch, R=regular lunch

* See the graph in the figure below for interpretation of this significant interaction.



New Standards (NS) math scores for ethnicity and SES subgroups.

Appendix C

Results from Factorial Analyses of Variance for the Math Coursework Data

To determine which of the differences in subgroup means were statistically significant, three-factor ANOVAs were conducted. The first three rows in the following table present the results for the main effects of gender, ethnicity, and SES for each of the three indicators (GPA total, GPA math, and course total). Consistent with the group means and effect sizes in the table above, the main effects of gender, ethnicity, and SES were significant for the two GPA variables (total and math). For the course total variable, there were no significant differences in ethnicity subgroups nor in SES subgroups, but there was a difference between genders. Males had a significantly larger mean number of math courses than females, although the magnitude of the difference was rather small.

ANOVA results for GPA total, GPA math, and number of math courses taken.

	GPA Total			GPA Math			Course Total		
	F	p		F	p		F	p	
gender	41.91	<.001	M < F	17.51	<.001	M < F	7.28	.007	F < M
ethnicity	183.55	<.001	B < W	112.79	<.001	B < W	3.67	.056	
ses	44.85	<.001	F < R	18.83	<.001	F < R	1.48	.224	
G x E	.12	.729		.41	.520		1.29	.256	
G x S	.68	.409		.89	.346		6.05	.014	
E x S	3.93	.048		3.44	.064		.01	.969	
G x E x S	.10	.755		.94	.333		.01	.939	

Note: $\alpha < .01$ was used to determine significance. The third column for each variable indicates which direction the means differed. M=males, F=females, B=black, W=white, F=free/reduced lunch, R=regular lunch

The table above indicates that there were no interaction effects among any of the demographic variables. This outcome was similar to the results for the three math assessments. The pattern of GPAs was similar for black and white students within SES. Table 5 in the Report showed the means, standard deviations, and effect sizes of GPA total and GPA math for each subgroup. The following table shows the subgroup means for the course total indicator.

Demographic means, standard deviations, and effect sizes for the course total indicator.

	Gender			Ethnicity			SES		
	male n=532	female n=725	ES	black n=546	white n=711	ES	free/red n=530	regular n=727	ES
Course	3.11	3.06	.15	3.11	3.06	.15	3.10	3.06	.12
Total	(.38)	(.31)		(.39)	(.30)		(.38)	(.31)	

Note: ES is Cohen's effect size (d).

Appendix D

Complete Correlation Matrix for Mathematics Assessment and Coursework Indicators

Scaled scores were used for the PSSA, TN, and NS. GPA math is the cumulative grade point average for math courses taken during 9th, 10th, and 11th grades. Course total is the number of math courses taken from 9th to 11th grades. Course type is a dichotomous variable – core courses only and core plus advanced courses.

Correlation matrix for scores on three mathematics assessments and three math coursework indicators.

	PSSA	TN	NS	GPA math	course total	course type
PSSA	---					
TN	.780*	---				
NS	.859*	.798*	---			
GPA math	.672*	.524*	.662*	---		
course total	-.024	-.032	-.057	-.111*	---	
course type	.557*	.522*	.612*	.403*	.102*	---

* p<.001

Appendix E
Complete Correlation Matrices for Mathematics Assessment
and Coursework Indicators by Gender, Ethnicity, and SES

Correlation matrix for scores on three math assessments and three math coursework indicators by gender.

	PSSA	TN	NS	GPA math	course total	course type
PSSA	---					
TN						
males ¹	.768*	---				
females	.791*					
NS						
males	.867*	.775*	---			
females	.855*	.823*				
GPA math						
males	.668*	.498*	.663*	---		
females	.689*	.562*	.664*			
course total						
males	-.076	-.077	-.123	-.123	---	
females	.016	.005	.004	-.092		
course type						
males	.671*	.516*	.646*	.433*	.065	---
females	.513*	.531*	.586*	.382*	.137*	

* p<.001

¹Sample sizes are 546 for males and 752 for females.

Correlation matrix for scores on three assessments and three math coursework indicators by ethnicity and ses.

	PSSA	TN	NS	GPA math	course total	course type
PSSA	---					
TN						
black, free/red ¹	.645*	---				
black, regular	.711*					
white, free/red	.661*					
white, regular	.755*					
NS						
black, free/red	.731*	.664*	---			
black, regular	.794*	.766*				
white, free/red	.806*	.644*				
white, regular	.829*	.774*				
GPA math						
black, free/red	.579*	.347*	.543*	---		
black, regular	.617*	.521*	.588*			
white, free/red	.513*	.266*	.517*			
white, regular	.633*	.489*	.631*			
course total						
black, free/red	-.001	-.029	-.107	-.174*	---	
black, regular	.049	.052	.024	-.041		
white, free/red	-.160	-.061	-.121	-.288*		
white, regular	.039	.032	.018	.013		
course type						
black, free/red	.298*	.225*	.341*	.263*	.016	---
black, regular	.412*	.429*	.463*	.332*	.229*	
white, free/red	.400*	.331*	.493*	.121	.072	
white, regular	.587*	.579*	.664*	.401*	.168*	

* p<.001

¹Sample sizes are 364, 182, 166, and 545 for black, free/red; black, regular; white, free/red; and white, regular lunch students, respectively.

Appendix F

Results of Regression Analysis to Predict PSSA Performance

Selected regression results when including demographics and the full set of math indicators.

	R ²	Beta	p
Model 1			
Demographics Only	.265		
ethnicity		.381	<.001
ses		.219	<.001
Model 2			
Demographics & All Math Indicators	.785		
ethnicity		.034	.037
ses		.020	.187
NS		.491	<.001
TN		.256	<.001
GPA math		.181	<.001
Course total		.027	.041
Course type		.034	.048
Model 3			
Demographics & Assessments Only	.766		
ethnicity		.036	.031
ses		.020	.194
NS		.626	<.001
TN		.260	<.001
Model 4			
Demographics & Coursework Only	.605		
ethnicity		.193	<.001
ses		.085	<.001
GPA math		.466	<.001
Course total		.004	.823
Course type		.297	<.001

The following table presents the average difference in actual versus predicted PSSA scores for black free/reduced, black regular lunch, white free/reduced lunch, and white regular lunch students for Models 2, 3, and 4. For Models 2 and 3, the average differences are small for each student subgroup due to the large R^2 values.

Average differences between actual and predicted PSSA math scores for each ethnicity/SES subgroup.

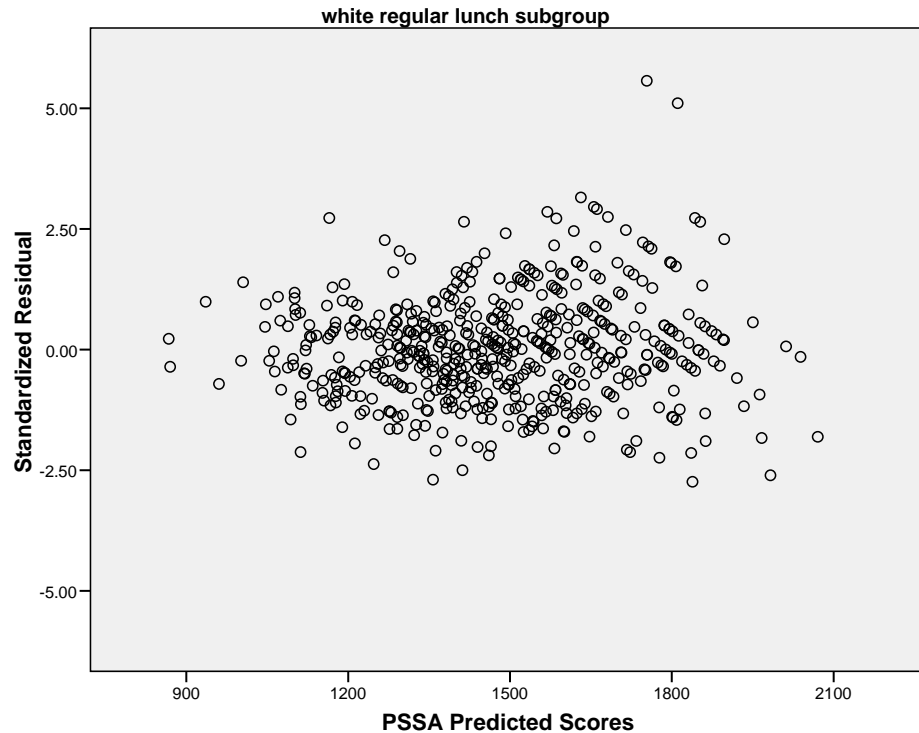
	Model 2	Model 3	Model 4
	All achievement indicators	Assessments only	Math Coursework only
black, free/red	1.10	1.27	5.73
black, reg	-2.20	-2.54	-11.46
white, free/red	-2.41	-2.79	-12.56
white reg	0.74	0.85	3.83

In Model 2, the smallest difference occurs in the white regular lunch group. The average difference between the actual (1474.48) and predicted (1473.74) PSSA math scores is 0.74 points. The two largest differences occur in the black regular lunch and white free/reduced lunch subgroups, and both differences are negative. This indicates a slight overestimation of the PSSA scores for these two groups.

Results for Model 3 (assessments only) are similar to Model 2. The average differences in actual and predicted PSSA scores are low for all student subgroups. In addition, the two negative residuals are associated with the black regular and white free/reduced lunch groups, indicating a slight overestimation of scores.

For Model 4 (coursework only), the residuals are higher due to the slightly lower R^2 in this model. The two largest residuals are in the white free/reduced lunch group (-12.56) and the black regular lunch group (-11.46). Both residuals are negative which represents an overestimation of actual PSSA scores.

The variance of residuals was also examined. Residual plots showed that the standardized residuals were randomly scattered about the horizontal line for three of the four subgroups. However, for the white regular lunch subgroup, the variance of the residuals appeared to increase as predicted PSSA scores increased, thus demonstrating heteroscedasticity. This occurred for Models 2 and 3, but not Model 4. The figure below shows the residual plot for Model 2. The plot for Model 3 looked similar.



Residual plot for Model 2 for the white regular lunch subgroup.

The regression models were evaluated in other respects. For instance, the distributions of residuals were examined to determine if they were normally distributed. Three of the four subgroups were normal according to skewness and kurtosis values and Shapiro-Wilk's tests. However, the white regular lunch subgroup distribution was positively skewed. There were also several outliers in this group.