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Longitudinal Math Data Analysis

Prepared for Arlington Public Schools

The following report summarizes math performance trends of Arlington Public Schools (APS) students. We analyze course level data and examination scores to determine patterns in math achievement. We segment the analysis by various demographic groups including race, gender and economically disadvantaged status to estimate potential gaps between groups. We conclude by examining the relationship between course level and academic performance.

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Executive Summary

The primary goal of this report is to provide Arlington Public Schools with a longitudinal analysis of its students' math performance. We evaluate two measures of performance: math course level and academic test scores. The data, which span from the 2003 to 2009 school year, are supplied by APS. The data coverage is for 817 students who enrolled in the school district from the third grade to ninth grade.

The math course level measure is broken down into four main groups: accelerated, grade-level, remedial, and self-contained. Course level data are available for both summer and regular school year. We analyze the data to identify course level trends over time.

Student test scores originate from two types of tests: (1) the Virginia Department of Education's Standards of Learning (SOL) Test and (2) Pearson Education's Stanford 10 Achievement Test. With the exception of grade four, data are available for grades three through nine for the SOL test. In contrast, data for the Stanford 10 test are only available for grades four and six.

The dataset provided also includes students' demographic data. Demographic information includes race, gender, LEP (Limited English Proficiency) status, economically disadvantaged status, and SPED (Special Education) status. Additionally, we were also given data on student attendance from the 2003 to 2009 school year. We segment both math achievement and course level analyses using these demographic data/attendance records. The overarching objective is to determine whether there are differences within and between these groups of students.

The report is divided into four sections. In *Demographic Information* we briefly summarize the demographic data of our analysis group. In *Enrollment Patterns* we display the results of our course level analysis from 2003 to 2009. In *Achievement Trends* we provide findings from our analysis of the SOL and Stanford 10 examination results. *Enrollment Patterns* and *Achievement Trends* both include a subsection on group segmentation analysis. In *Relationship between Enrollment and Achievement* we exhibit findings from correlation and regression analyses between enrollment and achievement indicators. We answer specific relational questions posed by APS.

Key Findings

Enrollment Patterns

- There were a higher percentage of students enrolled in accelerated math programs in the eighth grade compared to other grades.
- Overall, students regressed into grade-level programs in the ninth grade (i.e., there were a higher percentage of students enrolled in grade-level programs in the ninth grade).
- White students were more likely to enroll in accelerated math programs compared to the rest of the group of students. On average, close to two-thirds of white students took accelerated programs.
- SPED students were the least likely group to enroll in an accelerated program (12 percent).
- The proportion of black students in remedial/self-contained courses nearly doubled from 17 percent in the sixth grade to 32 percent in the eighth grade.
- Male and female students were close enough in their course enrollment patterns that their differences were not statistically observable.

Achievement Trends

- Students recorded the highest average score in the third grade math SOL (520.7 average) and the lowest score in the sixth grade math SOL (403.4 average).
- The reason for the low average score in the sixth grade SOL is due to the fact that (a) well performing sixth graders had enrolled in accelerated courses, and (b) these students' test scores are factored into the seventh or eighth grade SOL test scores.
- Stanford test takers in the sixth grade performed better than fourth grade test takers (68.6 average vs. 61.5 average).
- Those who are white, male, Asian and/or have above average attendance tend to score higher than other students on the SOL test.
- Students who are female, Hispanic, black, and/or have LEP, SPED, and economically disadvantaged designations performed below average on the SOL test. Those with below average attendance also did poorly on the SOL test.
- Group trends on the Stanford 10 test are similar to the group trends on the SOL test.

- In regard to SOL scores, there is a general downward trajectory for every student group from the third grade to the sixth grade. From the sixth grade onwards, there was a general upward movement in SOL scaled scores.
- In general, there appears to be a convergence between student SOL test scores as students approached the ninth grade. In essence, the difference in test scores between groups became smaller after the sixth grade.

Relationship between Enrollment and Achievement

- We determined that there is a moderate and positive correlation between test scores and math course level.
- Fifth grade Pass Advanced students performed significantly better (on the eighth grade SOL and Algebra I SOL) than Pass Proficient students, who in turn performed significantly better than Fail status students.
- While we were unable to find a strong relationship between attendance and test scores, we were able to determine that those who had above average attendance tended to perform better than those who had below average attendance.
- There is hardly any association between days of attendance in one school year and the corresponding course enrollment level in the following school year.
- From a regression analysis, we determined that all but two indicators included in the model influence a student's SOL test score. The two indicators that are not found to be statistically significant, when controlling for other factors, are gender and economically disadvantaged status. By contrast, factors such as race, LEP and SPED status, attendance, summer course enrollment, and level of course taken influence a student's SOL test score in a statistically significant way.

Demographic Information

Of the 817 students for whom we have data, slightly more than half were identified as white (Figure 1). Because of the low number of American Indian students and students with unspecified race, we exclude these students from the remaining analysis. There were slightly more female than male students in the dataset (Figure 2).

Figure 1: Race

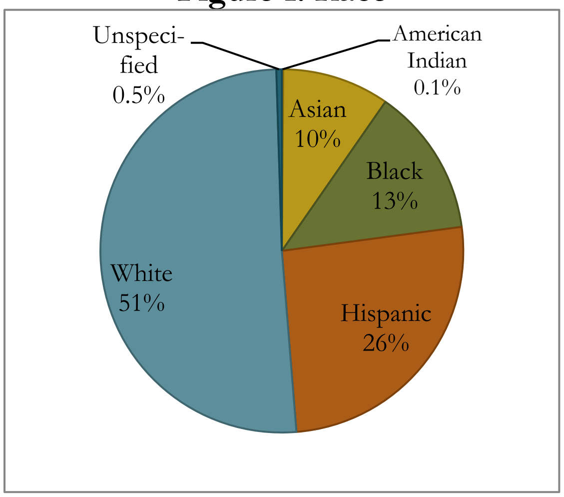
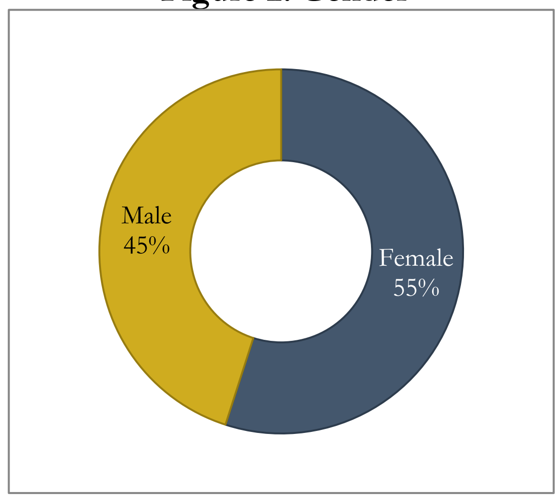
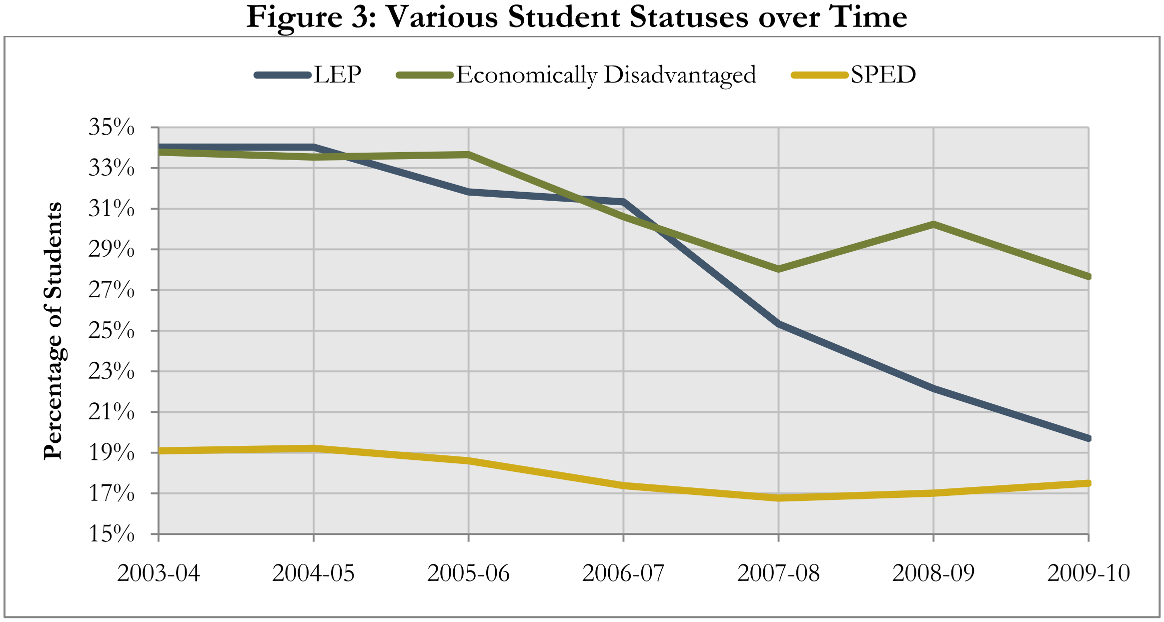


Figure 2: Gender



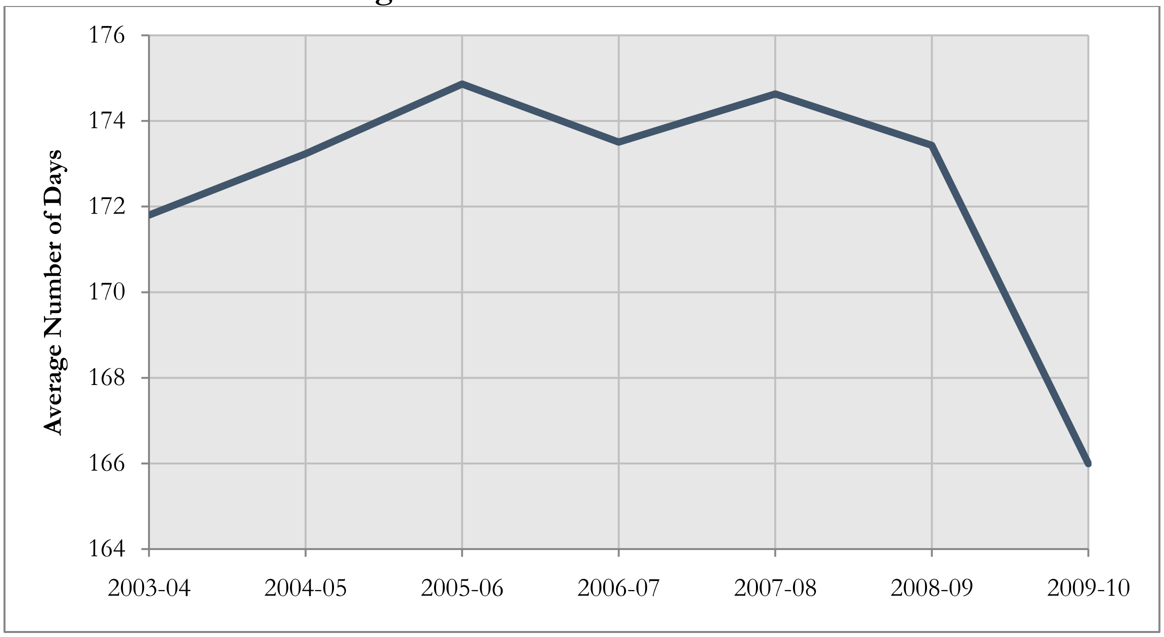
The **proportion of LEP (Limited English Proficiency) students fell** from 34 percent in 2003 to 20 percent in 2009. Similarly, the **number of students that were economically disadvantaged also fell** in the same time period (34 percent in 2003 vs. 28 percent in 2009). The percentage of students with SPED designation remained relatively unchanged over time.

Figure 3: Various Student Statuses over Time



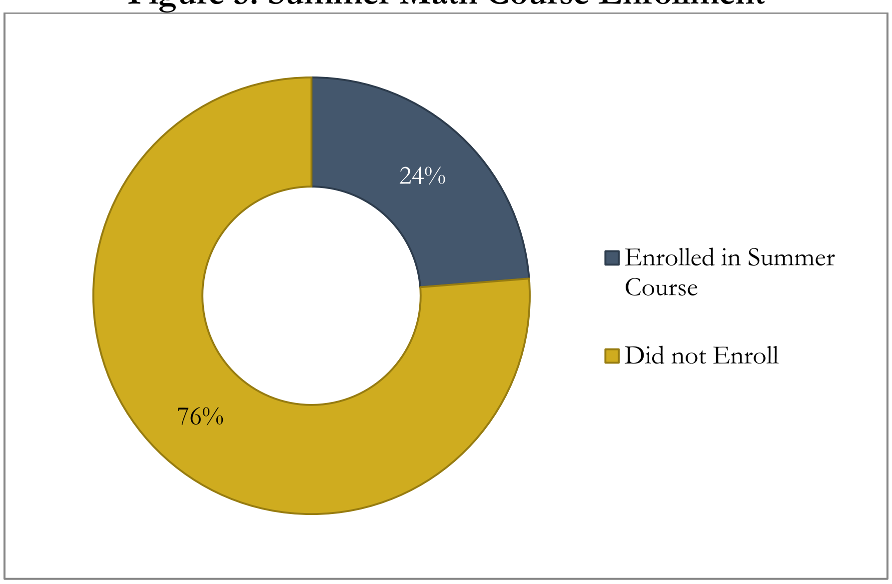
Overall, student attendance fluctuated mildly between 2003 and 2008. Students averaged 173.6 days of attendance during this time period. By contrast, attendance dropped dramatically to 166 days per student in the 2009 academic year.

Figure 4: Attendance over Time



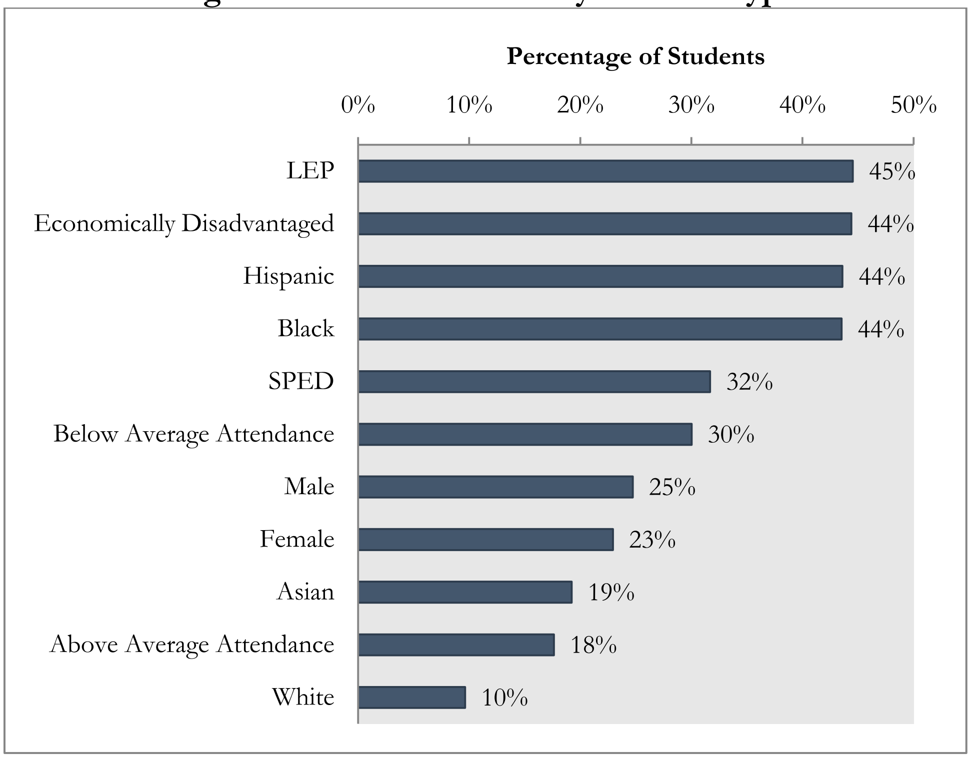
When it comes to summer enrollment, around a quarter of students have enrolled in at least one summer math course between 2006 and 2009. Note that summer session data are only available beginning in 2006.

Figure 5: Summer Math Course Enrollment



Approximately **45 percent of LEP students enrolled in at least one summer math course** between 2006 and 2009. Other student groups with high propensity for summer enrollment include economically disadvantaged, Hispanic and black students (44 percent each). White students are the least likely of any student group to enroll to in summer courses: Only 10 percent of all white students have taken any math courses in the summer.

Figure 6: Summer Course by Student Type



Enrollment Patterns

In this section we examine trends in students' math course level (i.e., course category) over time. Course level is measured by four main categories: accelerated, grade-level, remedial, and self-contained. Data for course level are only available from 2006 to 2009.

Overall Enrollment

The number of students who took math courses declined, to some extent, from 805 in 2006 to 789 in 2009 (Figure 7). In regard to summer session, the number of math students declined considerably in 2009 (28 total enrollment) only to increase again in 2010 (85) (Figure 8).

Figure 7: Overall Number of Enrollment – School Year

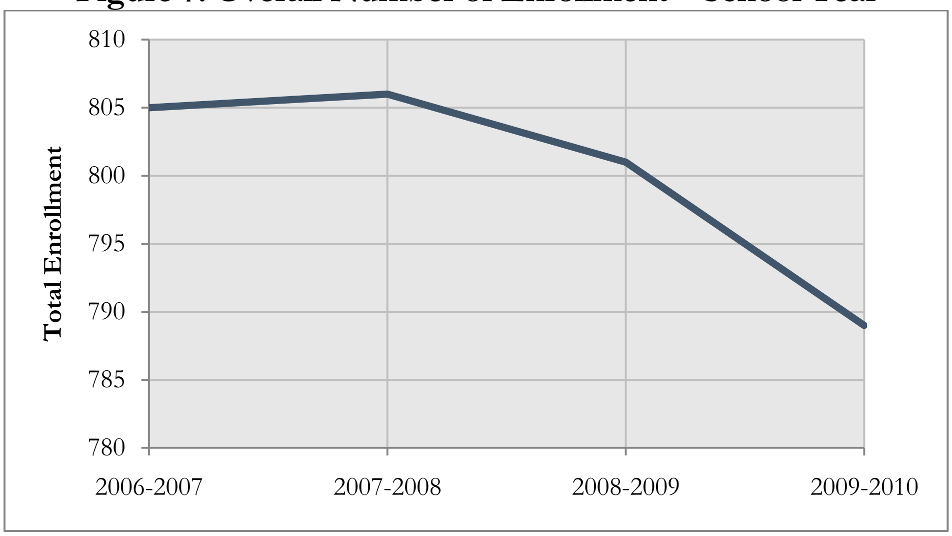
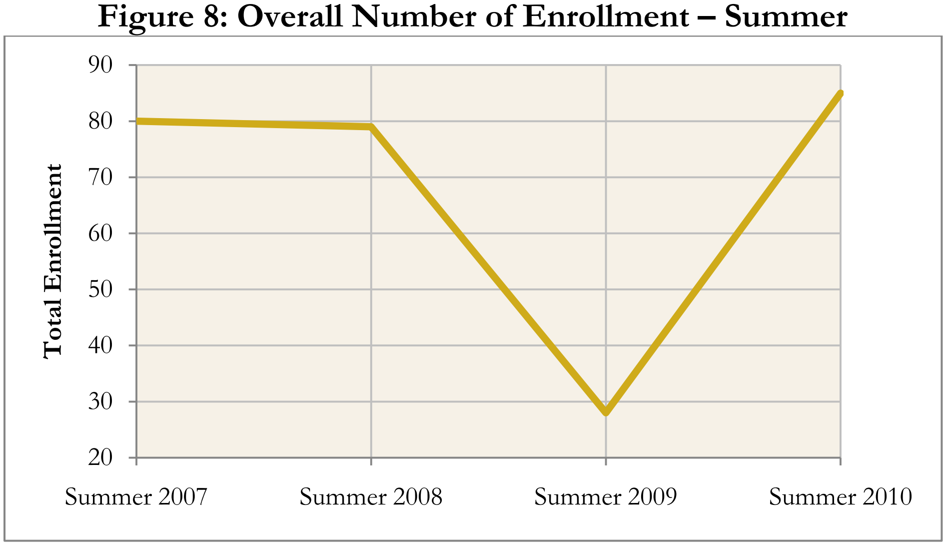


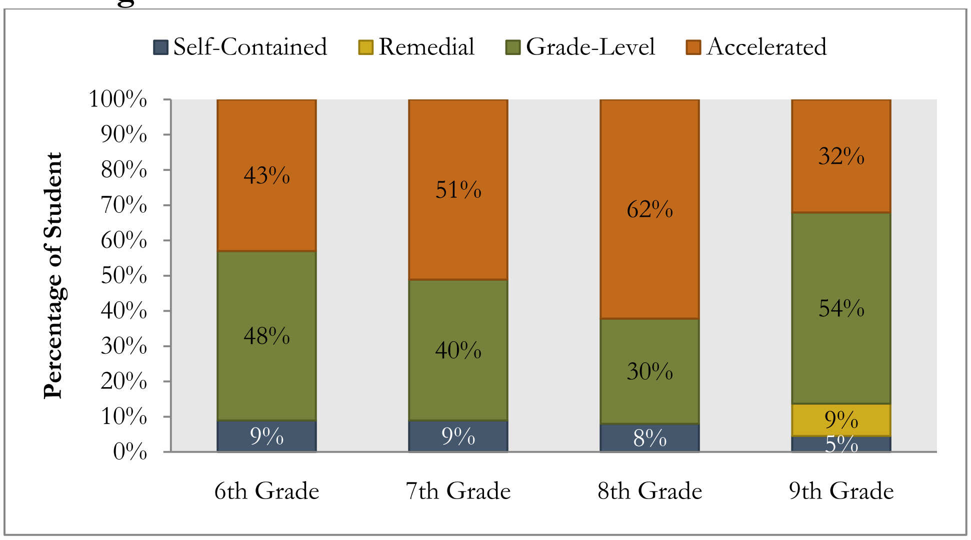
Figure 8: Overall Number of Enrollment – Summer



The following graphs present course category breakdowns by grade-level. To reiterate, sixth grade corresponds to 2006-07 enrollment, seventh grade to 2007-08 enrollment, etc.

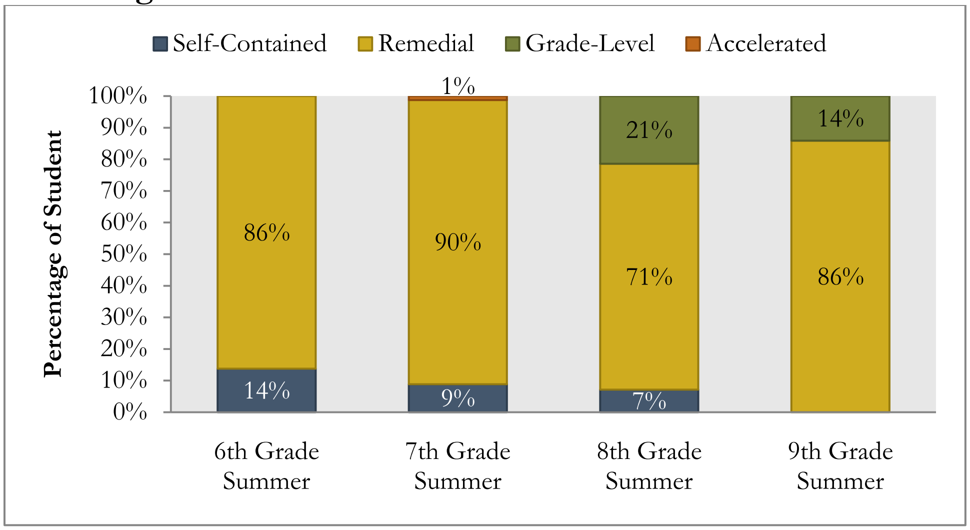
In the regular school year, there **were more students in accelerated math programs in the eighth grade compared to other grades**. However, students **regressed into grade-level programs in the ninth grade** (i.e., there was a higher percentage of students enrolled in grade-level programs in ninth grade). Additionally, the only instance in which remedial programs appeared in the regular school year is during the ninth grade (2009-10).

Figure 9: Math Course Level Breakdown - School Year



In contrast to the regular school year, **most summer courses consist of remedial type programs**. There does not appear to be much change in the composition of summer courses over the measured timeframe.

Figure 10: Math Course Level Breakdown - Summer



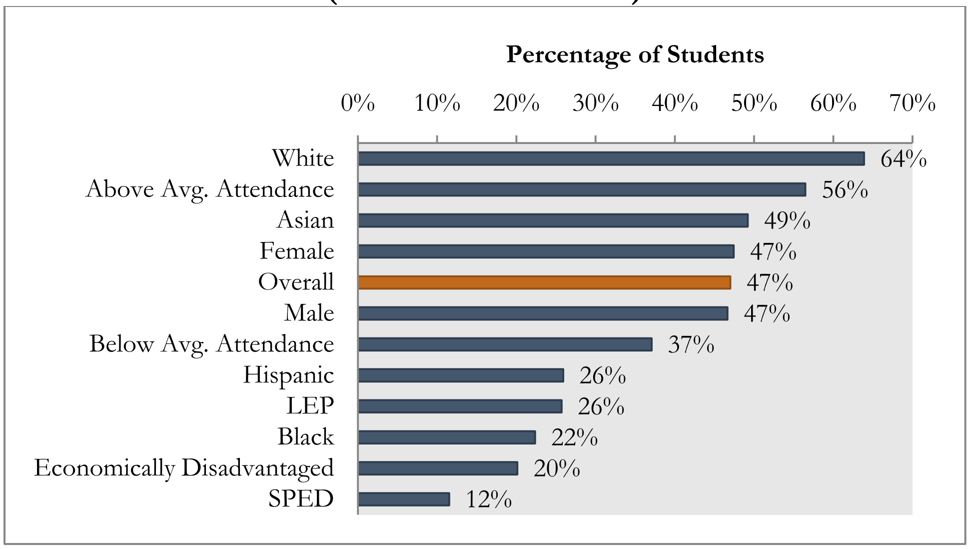
Enrollment Patterns by Student Type

We segmented the course level analysis into various student groups. We analyzed remedial and self-contained programs jointly since both programs had few enrollees. All four years of available data (2006 to 2009) were then combined to formulate the first three graphs. We then illustrate course level change by group, longitudinally. We provide an overall average measure to get a general idea of which group is performing well and which group is underperforming. We did not include, in our analysis, separate categories for students who are non-LEP, non-SPED, and not economically disadvantaged. In other words, in the figures below, we display a separate "LEP" category but do not display a separate "non-LEP" category. The comparison for these students is included in the appendix.

We could not provide the same types of graphs for summer courses as there are too few variations in the course level offered (i.e., most courses are remedial in nature). However, based on two of the graphs above (Figure 6 and Figure 10) we could infer that **LEP, economically disadvantaged, Hispanic and black students need more remedial help in the summer** than any other group of students. While Figure 6 shows that these students have a high likelihood of enrolling in a summer course, Figure 10 shows that most summer courses are remedial in nature.

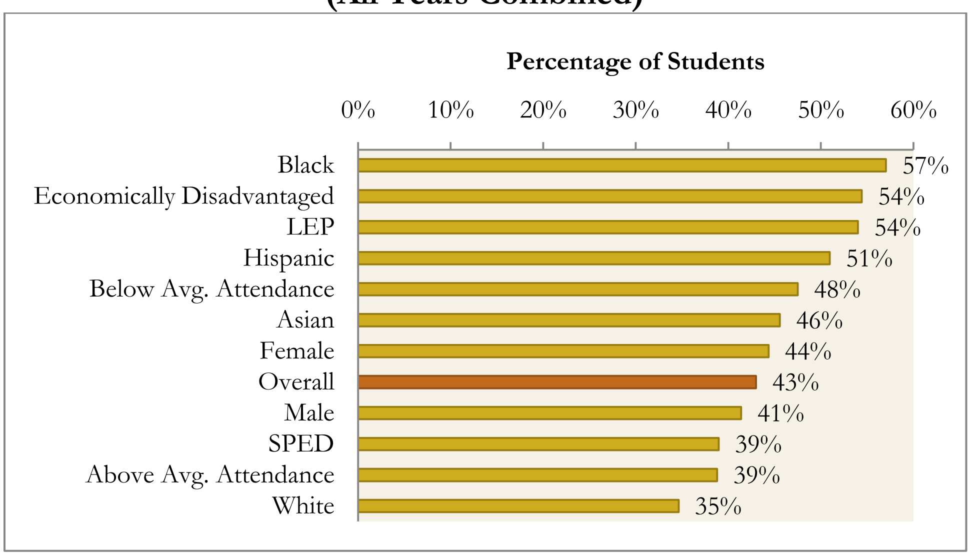
In regard to course level in the regular school year, **white students were more likely to enroll in accelerated programs** compared to the rest of the segmented group of students. On average, close to two-thirds of white students took accelerated programs. Male and female students were equally as likely to enroll in accelerated courses (47 percent each). **SPED students were the least likely** group to enroll in an accelerated program (12 percent).

Figure 11: Accelerated Program Enrollment by Type of Student (All Years Combined)



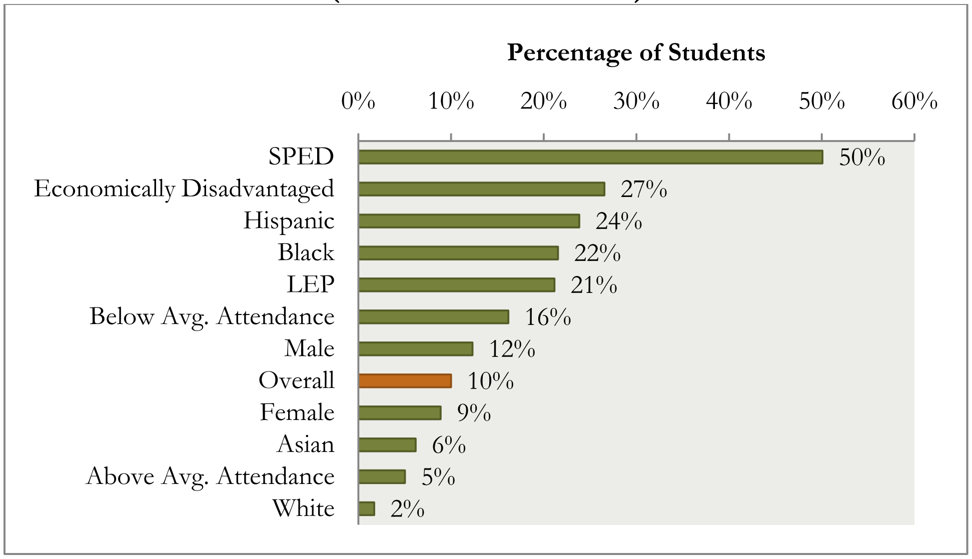
Black students were not well represented in accelerated math programs at APS. Only 22 percent of black students enrolled in advanced math programs between 2006 and 2009. **Black students were more likely to enroll in grade-level programs** (57 percent) (Figure 12, below). White students were the least likely of any of the observed groups to enroll in grade-level programs.

Figure 12: Grade-Level Program Enrollment by Type of Student (All Years Combined)



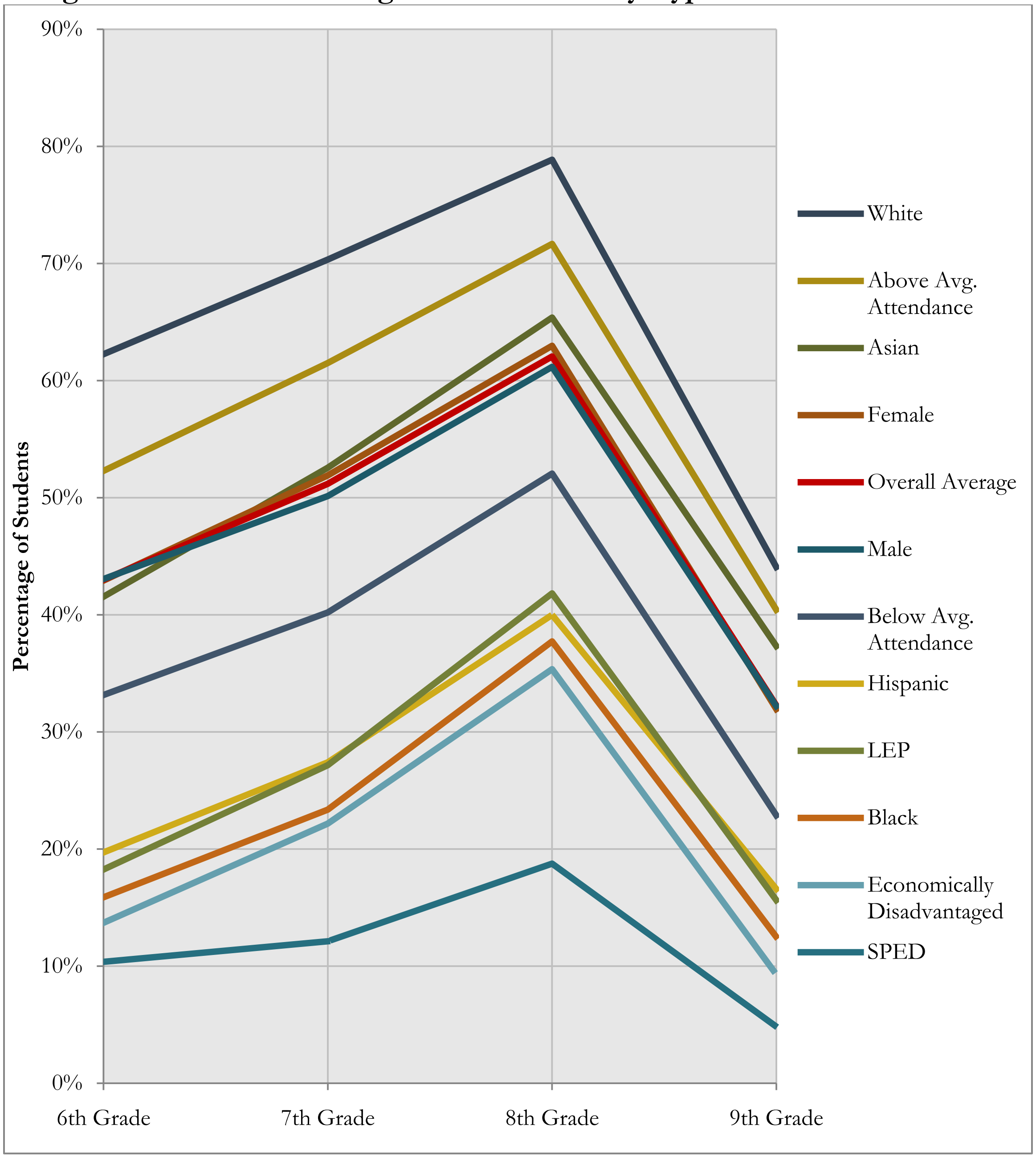
Overall, **approximately half of SPED students enrolled in remedial and self-contained programs**. Consistent with our findings – that white students tend to enroll in more advanced math courses – only two percent of white students enrolled in remedial/self-contained programs.

Figure 13: Remedial/Self Contained Program Enrollment by Type of Student (All Years Combined)



The next three graphs present course level findings by group over time. In general, there was a **spike in accelerated course enrollment** for every student group in the **eighth grade**. The proportion of accelerated students in the ninth grade is lower than any of the other grade levels, for all of the identified groups.

Figure 14: Accelerated Program Enrollment by Type of Student over Time

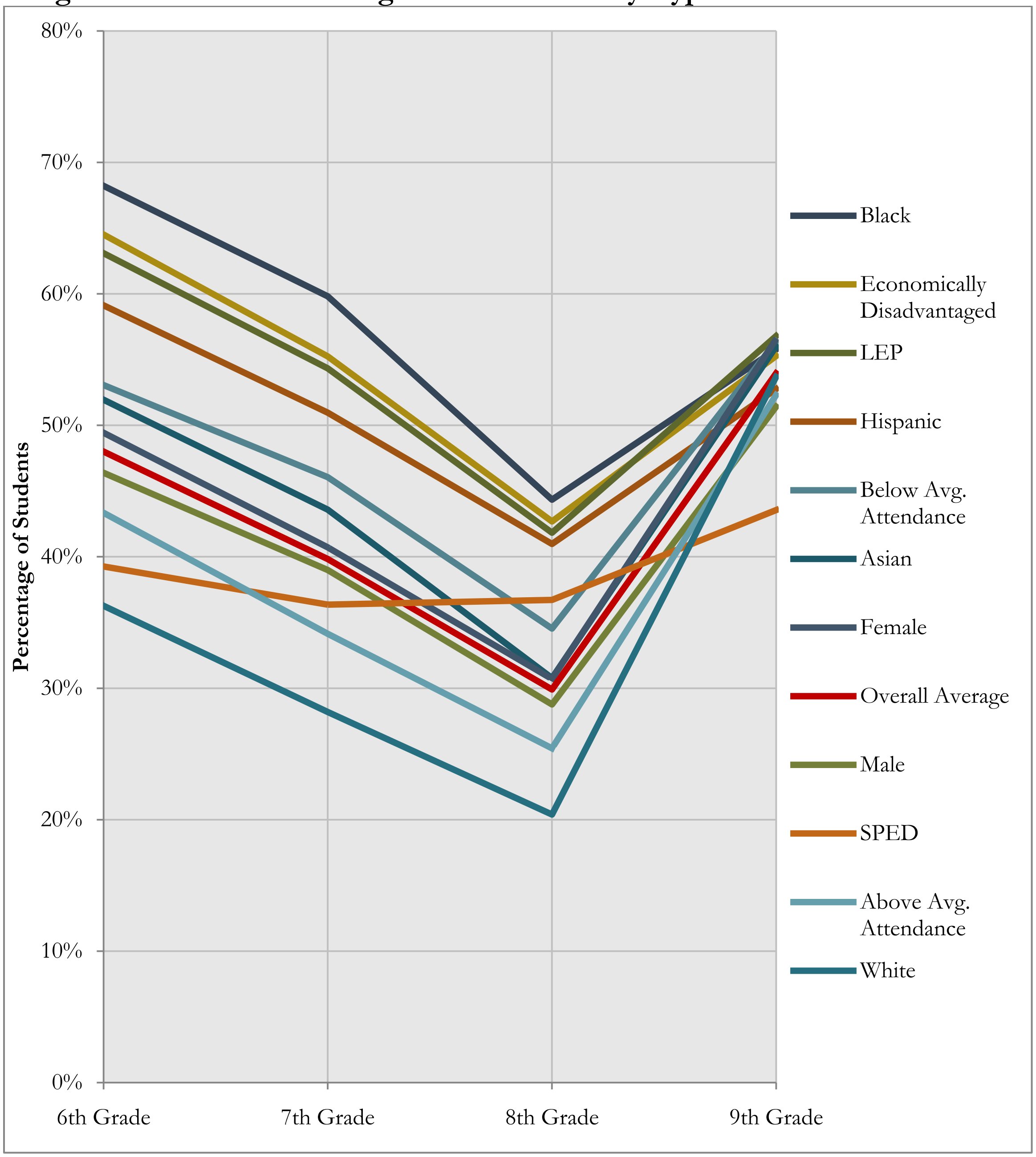


It is worth noting that **the year-to-year change does not impact the relative position of many of these groups**. For example, despite the increase in accelerated program enrollment in the eighth grade and the subsequent dip in ninth grade, white students remained the highest group to enroll in accelerated programs.

A similar pattern can be seen in grade-level enrollment over time (we ordered the graph legend to correspond to each group's placement relative to each other). Black students continued to be the most represented group in this course category from sixth to ninth grade. **In the eighth grade, there was a decline in grade-level**

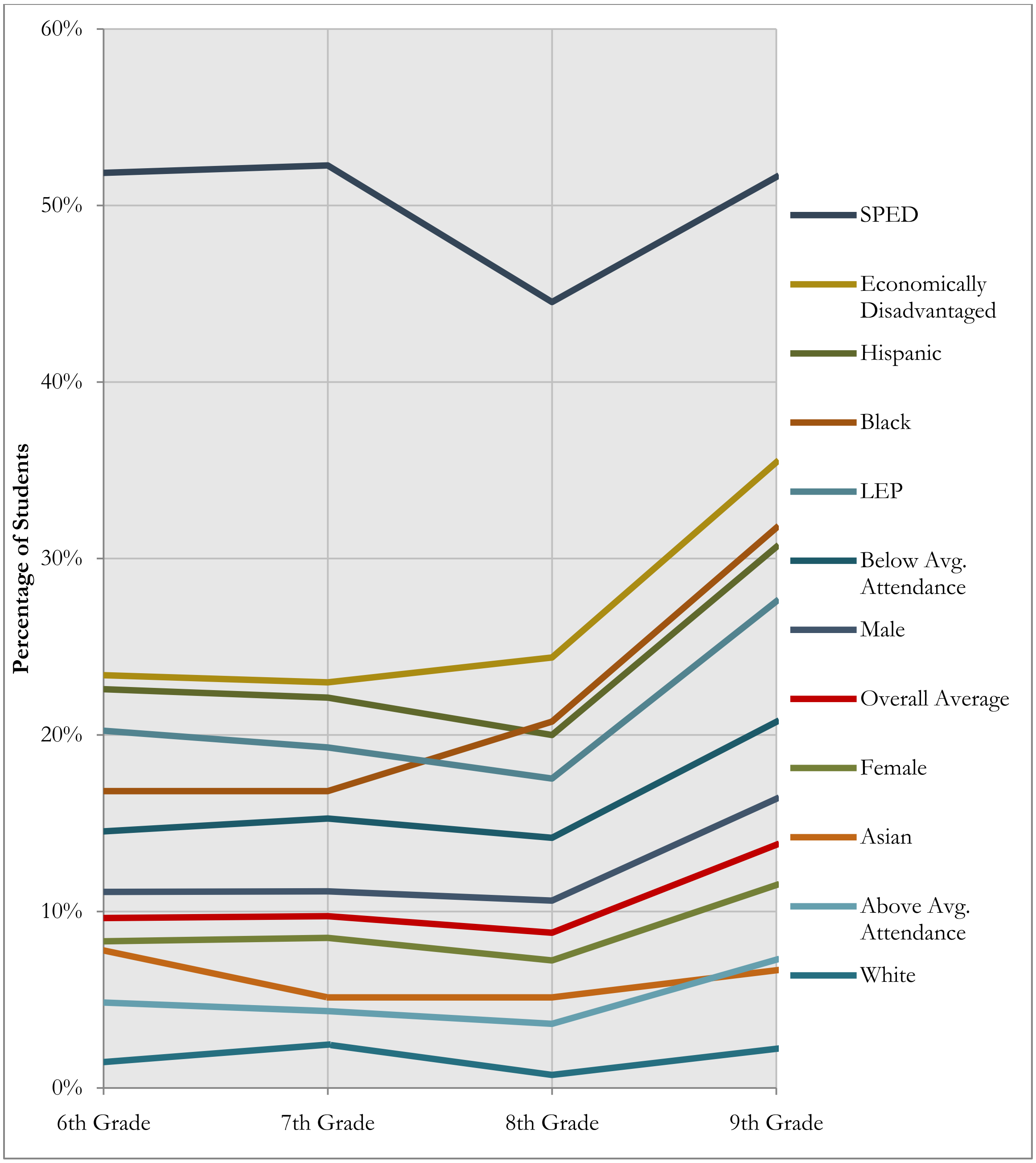
enrollment for almost all of the observed groups, to counterbalance the increase in accelerated course enrollment. SPED students appear to buck this enrollment pattern, wherein the group's enrollment in grade-level courses remained steady over time. The proportion of students in grade level course appears to be similar across groups in the ninth grade.

Figure 15: Grade-Level Program Enrollment by Type of Student over Time



When we examined remedial/self-contained course enrollment over time, we noticed that the **proportion of black students nearly doubled** from 17 percent in the sixth grade to 32 percent in the ninth grade. This is most likely due to the fact that remedial courses were introduced in the regular school year in the ninth grade, and that **black, Hispanic, LEP and economically disadvantaged students tend to enroll in remedial courses at higher rates** than other groups. The same four groups that had above average representation in accelerated program enrollment were below average in remedial and self contained program enrollment (white, above average attendance, Asian and female students).

Figure 16: Remedial/Self- Contained Program Enrollment by Type of Student over Time



While the graphs above exemplify differences *between* groups, the following table illustrates the differences *within* student groups (e.g., LEP vs. Non LEP students). Specifically, the table below provides the results of statistical testing to determine whether or not the difference within each demographic group is meaningful. Asterisks represent statistically significant findings (at p-value<0.01. Another way to interpret this is that we are 99 percent confident that the difference within groups marked with asterisks in course level enrollment is statistically significant).

In regard to regular school year enrollment, we witnessed **significant differences in the enrollment patterns within almost every group**. The one exception is between genders. Male and female students were close enough in their course enrollment patterns, that their differences were not statistically observable. In the summer, it appears that the difference in students' course level is negligible. The only statistically significant difference, in the summer, is between SPED and non-SPED students in the sixth and ninth grade.

See the appendix to visualize the actual course level difference between students who were designated LEP, SPED and economically disadvantaged and students who were not.

Table 1: Differences in Course Category within Group

Category	Race	LEP	SPED	Gender	Econ. Status	Atten-dance
Group Differences in Course Category – School Year						
6th Grade Course Category	***	***	***		***	***
7th Grade Course Category	***	***	***		***	***
8th Grade Course Category	***	***	***		***	***
9th Grade Course Category	***	***	***		***	***
Group Differences in Course Category – Summer						
6th Grade Summer Course Category			***			
7th Grade Summer Course Category						
8th Grade Summer Course Category			***			
9th Grade Summer Course Category						

*** Differences statistically significant at p-value<0.01

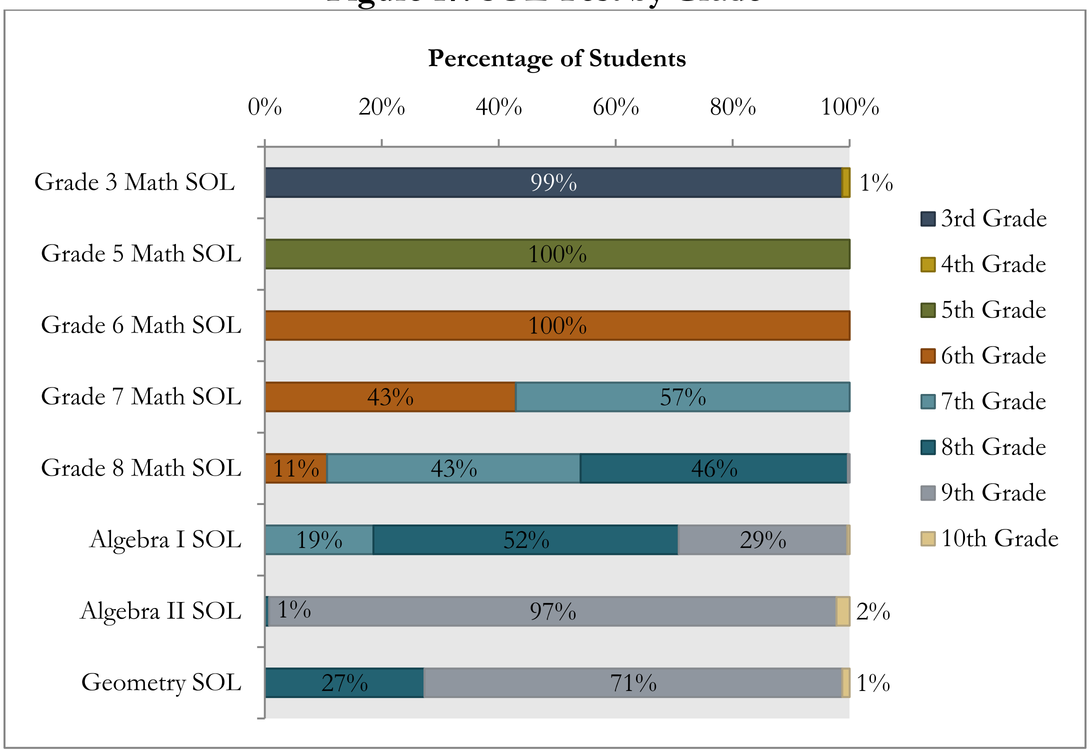
Achievement Trends

In this section we examine overall test score achievements as well as summarize test score gaps between identified groups and within these groups. The test scores are based on two exams: the Standards of Learning (SOL) test which is administered each year (*with the exception of fourth grade*), and the Stanford 10 test which is administered in grades four and six. We were given two measures of the SOL: performance level (a 1-5 rank) and scaled score (a score ranging from 193 to 600). We utilized the scaled score in our analysis as this measure has more variation.

Overall Achievement

To clarify, students are able to enroll in accelerated math courses beginning in grade six. Students in accelerated math programs take the SOL test that corresponds to their course level (e.g., an accelerated sixth grader would take the seventh grade SOL test). The figure below presents the distribution of SOL tests by grade level. As we can see, 43 percent of those who took the seventh grade SOL test were from the sixth grade, while the remaining 57 percent were from the seventh grade.

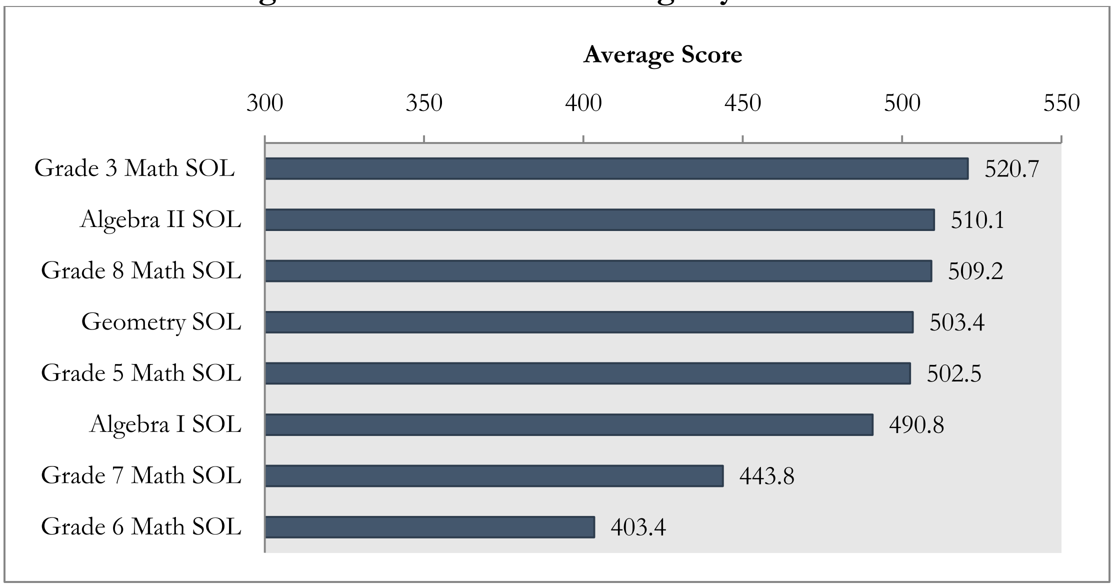
Figure 17: SOL Test by Grade



APS has requested that we examine achievement scores by grade level (e.g., how did sixth grade students perform on the SOL test, regardless of which SOL test they took). We therefore focus much of the discussion of our findings by grade-level.

Figure 18 displays the average SOL test score by test type. Students recorded the **highest average score in the third grade math SOL (520.7 average) and the lowest score in the sixth grade math SOL (403.4 average)**.

Figure 18: Scaled Score Average by SOL Test



The reason for the low average score in the sixth grade SOL is due to the fact that (a) high performing sixth graders had enrolled in accelerated courses, and (b) these students' test scores are factored into the seventh or eighth grade SOL test scores. Sixth graders who took accelerated courses scored 97 points higher than their peers, while sixth graders who took accelerated courses scored 174 points higher than their peers.

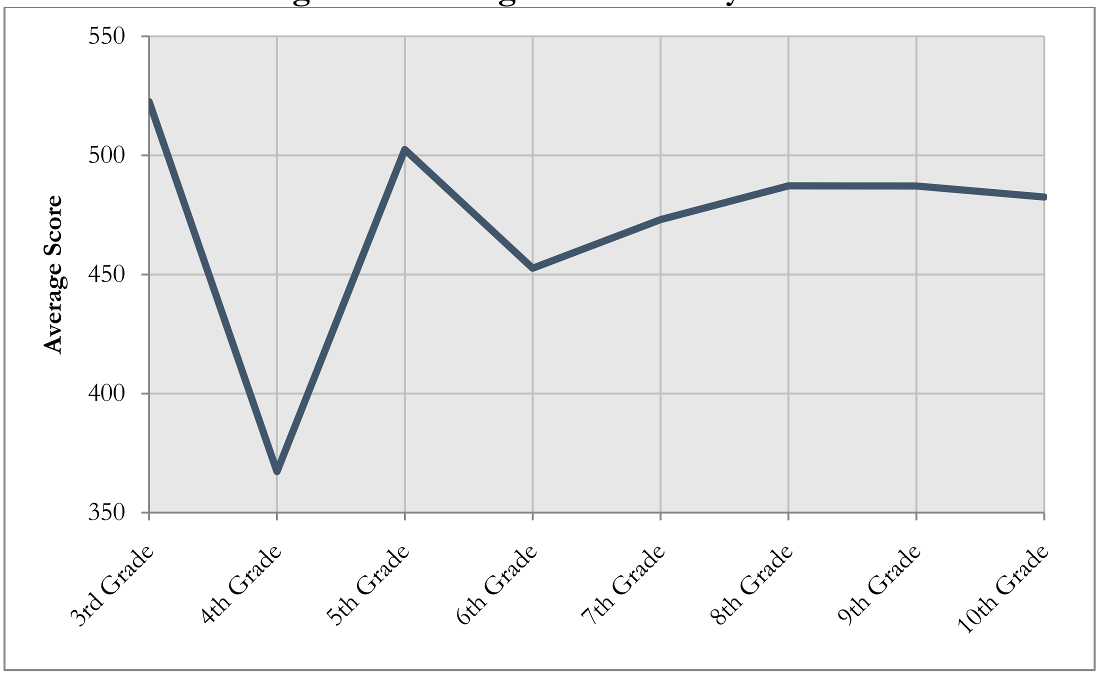
We highlight in yellow the grade with the highest score for each test. In every case, **students who are in accelerated programs performed better** than the rest.

Table 2: Average SOL Score by Grade and by Test

	6th Grade	7th Grade	8th Grade	9th Grade	10th Grade	Overall
Grade 6 SOL	403					403
Grade 7 SOL	500	402	-	-	-	444
Grade 8 SOL	575	545	461	326	-	509
Algebra I SOL	-	527	492	464	516	491
Algebra II SOL	-	-	600	510	479	510
Geometry SOL	-	-	532	493	468	503

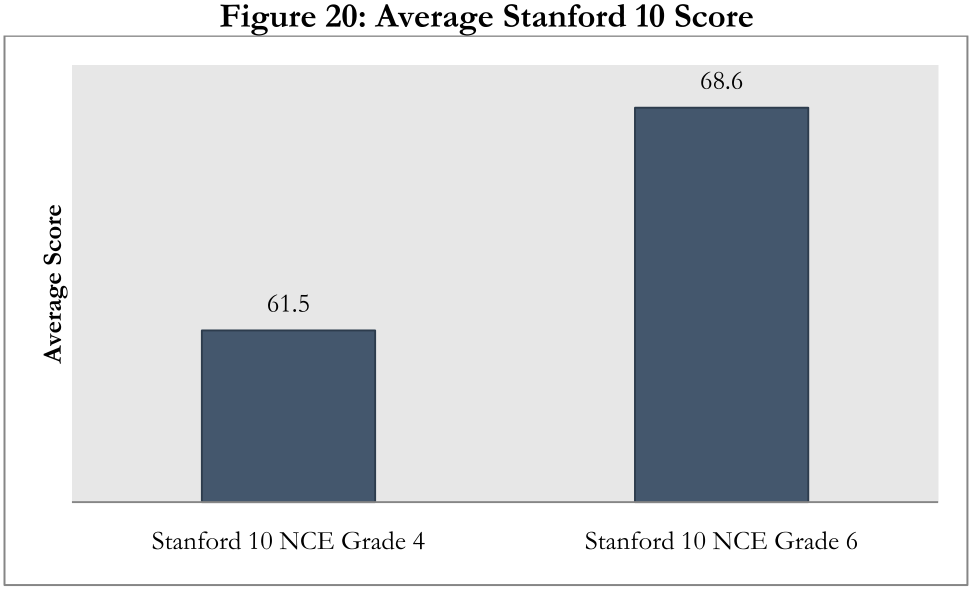
When we looked at scores by grade (regardless of the SOL year) we found that fourth grade students performed the worst on the SOL (367 average), while third grade students performed the best (522 average). The reason fourth grade students performed significantly worse than others is because these (nine) students took the third grade SOL test, suggesting that they were lagging behind other students in the fourth grade. For secondary school grade-level, those in the eighth grade performed the best in the SOL test (487), by a small margin.

Figure 19: Average SOL Score by Grade



The figure below details average perfomance on the Stanford 10 test. Stanford test takers in the **sixth grade performed better than fourth grade test takers** (68.6 average vs. 61.5 average).

Figure 20: Average Stanford 10 Score

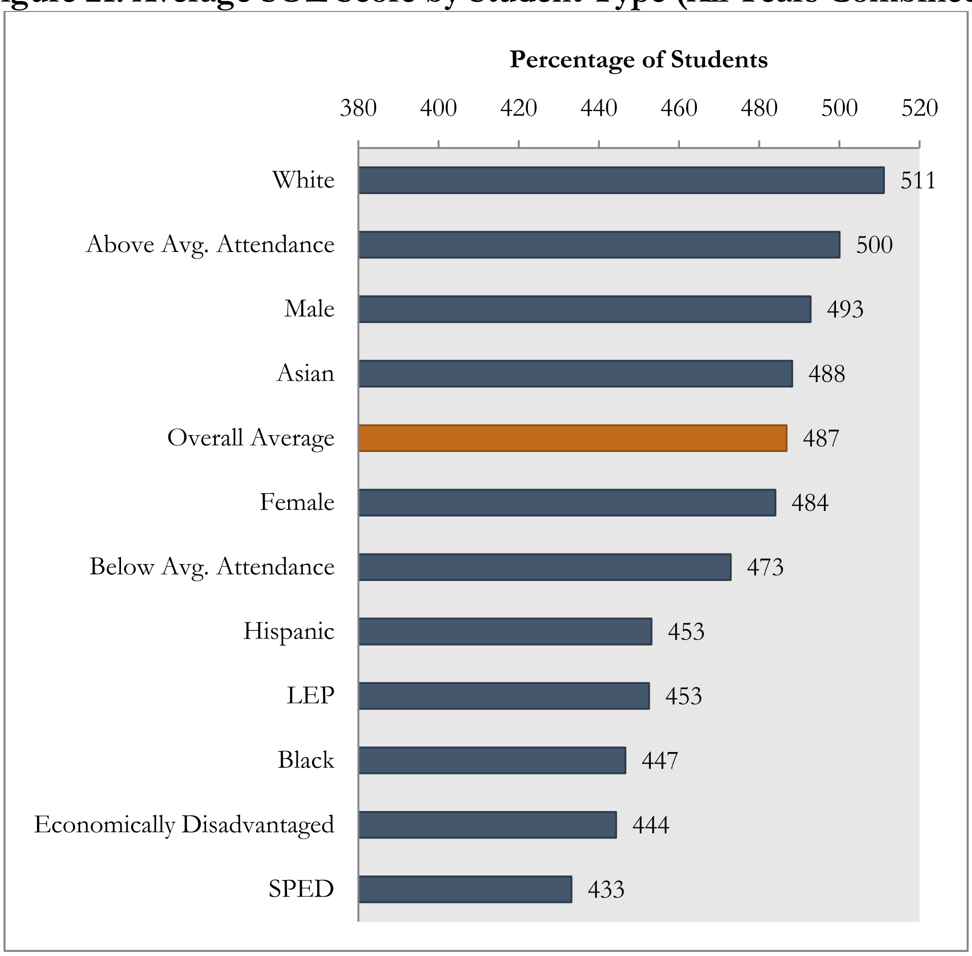


Achievement Trends by Student Type

In this subsection we segment the achievement findings above by student type. As with our analysis of enrollment patterns, we did not include separate categories for students who are non-LEP, non-SPED, and not economically disadvantaged. The comparison for these students is included in the appendix.

Those who are **white, male, Asian and/or have above average attendance tend to score higher** than the rest on the SOL test. Student groups that placed high on the SOL test measure also placed high on the accelerated course level measure (i.e., white students finishing at the top on both measures, students with above average attendance finishing second, etc.) (see Figure 11, above). Students who are female, Hispanic, black, and/or have LEP, SPED, and economically disadvantaged designations performed below average on the SOL test. Those with below average attendance also did poorly on the SOL test.

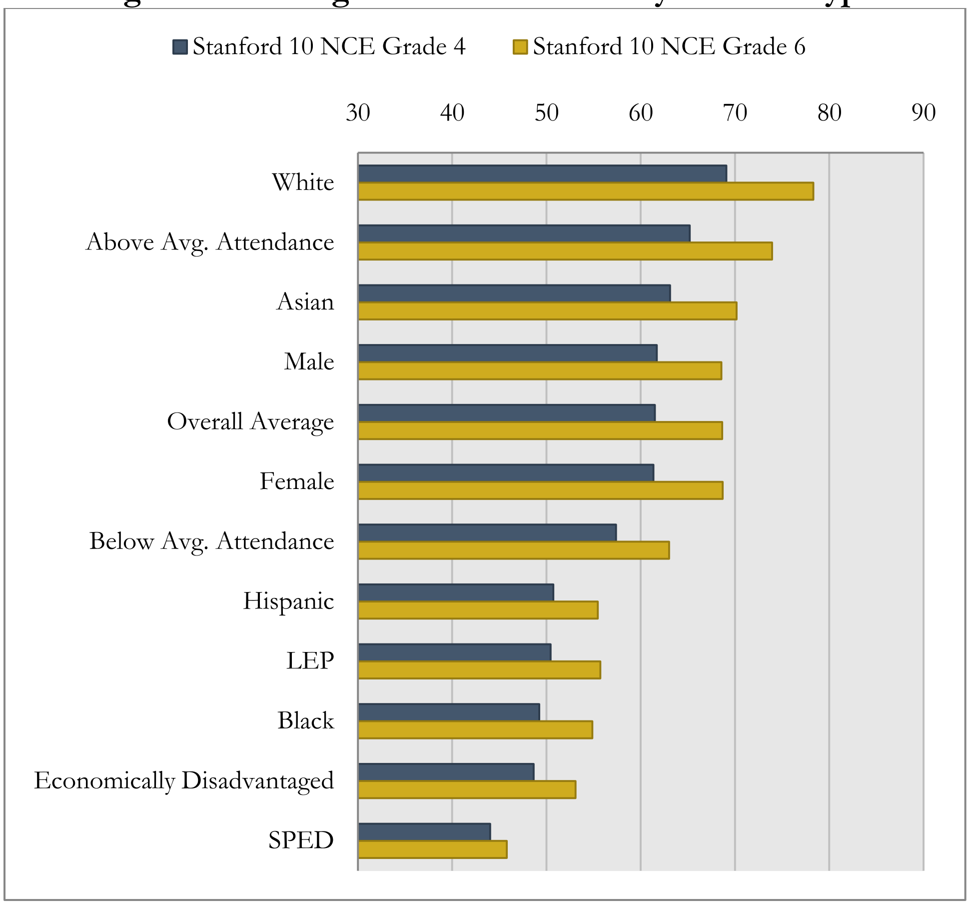
Figure 21: Average SOL Score by Student Type (All Years Combined)



One interesting finding is that while **females performed marginally better than males on the course level measure** – i.e., more female students enrolled in accelerated courses and fewer female students enrolled in remedial/self-contained classes (Figure 11 and 13, above) – **male students tend to do better on the SOL examination measure** (493 average score vs. 484 average score) (Figure 21, above).

The results for the Stanford 10 are presented below in the order of the highest to lowest performing group. Across all groups, students performed better in the sixth grade than in the fourth grade. The order of the groups for the Stanford 10 test is similar to that of the SOL test average.

Figure 22: Average Stanford 10 Score by Student Type

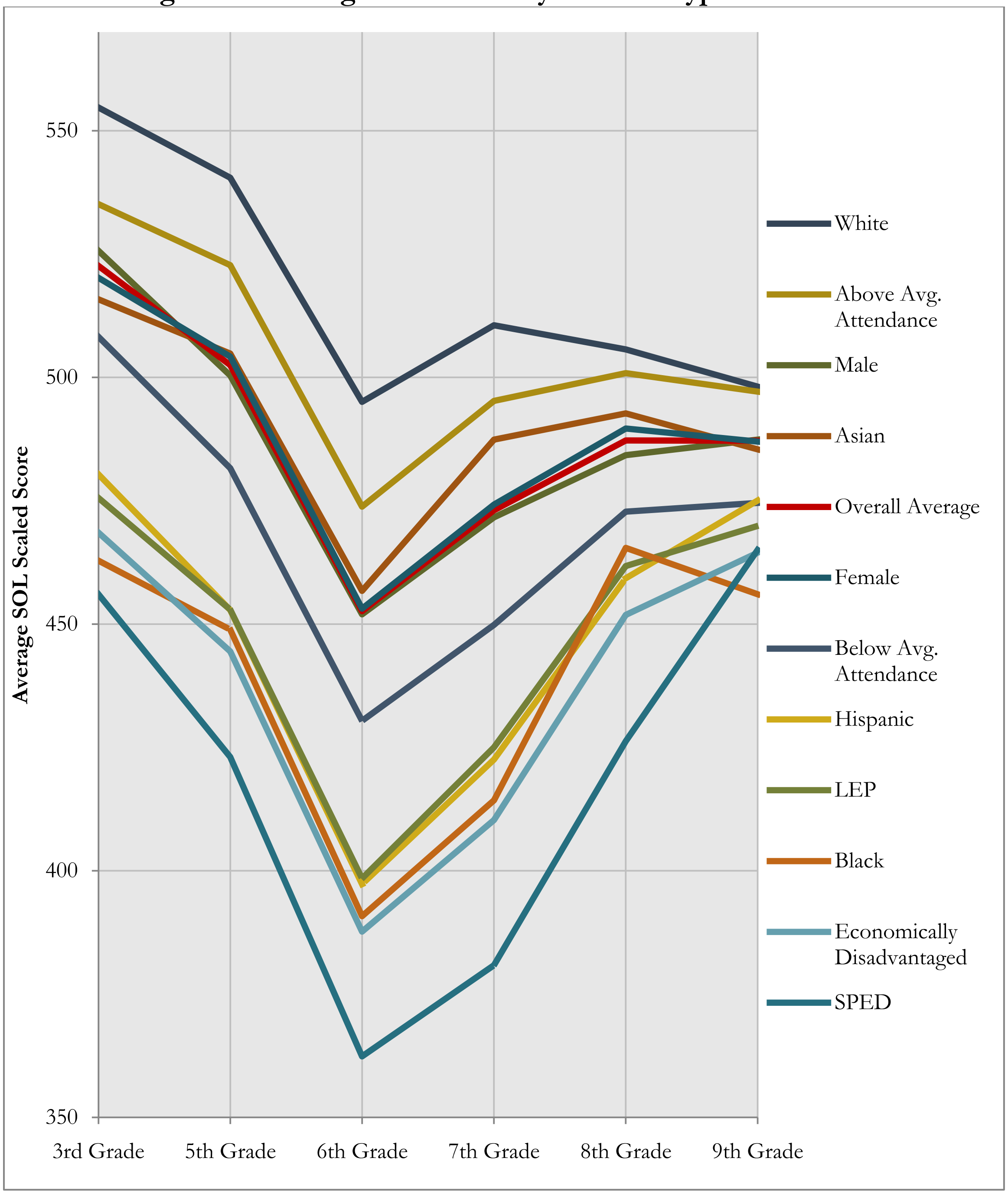


We next examine SOL score averages by student group over time. Because there are a very small number of fourth and tenth grade students (nine and 12 students, respectively), we omit these grade levels from the following analysis. While the following analysis focuses on the differences in test scores between student groups *by grade*, the breakdown of scores by student group *by test type* is presented in the appendix.

In regard to SOL scores, there is a **general downward trajectory for every student group from the third grade to the sixth grade**. From the sixth grade onwards, there was a general upward movement in SOL scaled scores. White students increased their SOL scores from the sixth grade to the seventh grade, but their scores decreased from the seventh grade to the ninth grade. Even so, white student still top most of the other observed groups in the ninth grade, although by a smaller margin.

In general there appears to be a **convergence between student test scores as students approached the ninth grade.** In essence, the difference in test scores between groups became smaller after the sixth grade.

Figure 23: Average SOL Score by Student Type over Time



We statistically tested for differences in test scores and discovered that within each group, test scores were markedly dissimilar. In other words, we are 99 percent confident that the difference between SOL test scores are different within race (e.g., white students tend to score highest, black students tend to score lowest), within LEP status (LEP status students tend to score lower than non-LEP students), etc.

The only category with similar (i.e., not statistically different) test score measures is gender. The differences in test scores between male and female students – similar to course level trends – were small and not statistically significant. Additionally, Algebra II is the only SOL test on which students scored similarly regardless of race, gender, student status, and attendance level.

See the appendix for actual test score differences between students who were designated LEP, SPED and economically disadvantaged and students who were not.

Table 3: Differences in Test Scores within Group

Category	Race	LEP	SPED	Gender	Econ. Status	Atten-dance
Group Differences in SOL Scaled Scores						
Grade 3 Math SOL	***	***	***		***	***
Grade 5 Math SOL	***	***	***		***	***
Grade 6 Math SOL	***	***	***		***	***
Grade 7 Math SOL	***	***	***		***	***
Grade 8 Math SOL	***	***	***		***	***
Algebra I SOL	***	***	***		***	***
Algebra II SOL						
Geometry SOL	***	***			***	***
Group Differences in Stanford 10 Scores						
Stanford 10 NCE Grade 4	***	***	***		***	***
Stanford 10 NCE Grade 6	***	***	***		***	***
Group Differences in SOL Scaled Scores by Grade						
3rd Grade Scaled Score	***	***	***		***	***
5th Grade Scaled Score	***	***	***		***	***
6th Grade Scaled Score	***	***	***		***	***
7th Grade Scaled Score	***	***	***		***	***
8th Grade Scaled Score	***	***	***		***	***
9th Grade Scaled Score	***	***	***		***	***

Relationship between Enrollment and Achievement

In this section we detail the relationship between course enrollment level and academic achievement. This section is presented in a question and answer format based on specific questions that we received from Arlington Public Schools.

What is the relationship between elementary test scores (3rd grade SOL, 4th grade Stanford 10, and 5th grade SOL) and secondary enrollment, particularly in 6th and 9th grade?

Correlation between Elementary Test Scores and Secondary Enrollment Level

We conducted a correlation analysis to determine the relationship between elementary test scores and secondary enrollment outcome (See the appendix for details on what a correlation analysis means and how to interpret a correlation table). The grade level in which APS is interested is highlighted in yellow.

From the analysis, we determined that there is a **moderate correlation between test scores and math course level**. The correlation is positive, meaning that as elementary test scores increase, so too does the likelihood of enrolling in a higher level secondary math course. The correlation level (close to 0.6) is about the same for every test score, meaning that past SOL and Stanford 10 scores are both moderately associated with students' future course level.

Table 4: Elementary School Grades and Secondary Course Category

	Grade 3 SOL SS	Grade 4 Stanford 10	Grade 5 SOL SS
Grade 6 Course Category	0.589	0.557	0.594
Grade 7 Course Category	0.570	0.565	0.597
Grade 8 Course Category	0.548	0.509	0.553
Grade 9 Course Category	0.569	0.569	0.569

Correlation Statistically Significant at $p<0.001$

What is the relationship between elementary test scores and later test scores? Specifically, look at 5th grade SOL passing groups (Pass Advanced, Pass Proficient, Fail) and see how the students in each of those groups did on whichever SOL test they took in 8th grade (8th grade SOL, Algebra I SOL, Algebra II SOL, or Geometry SOL).

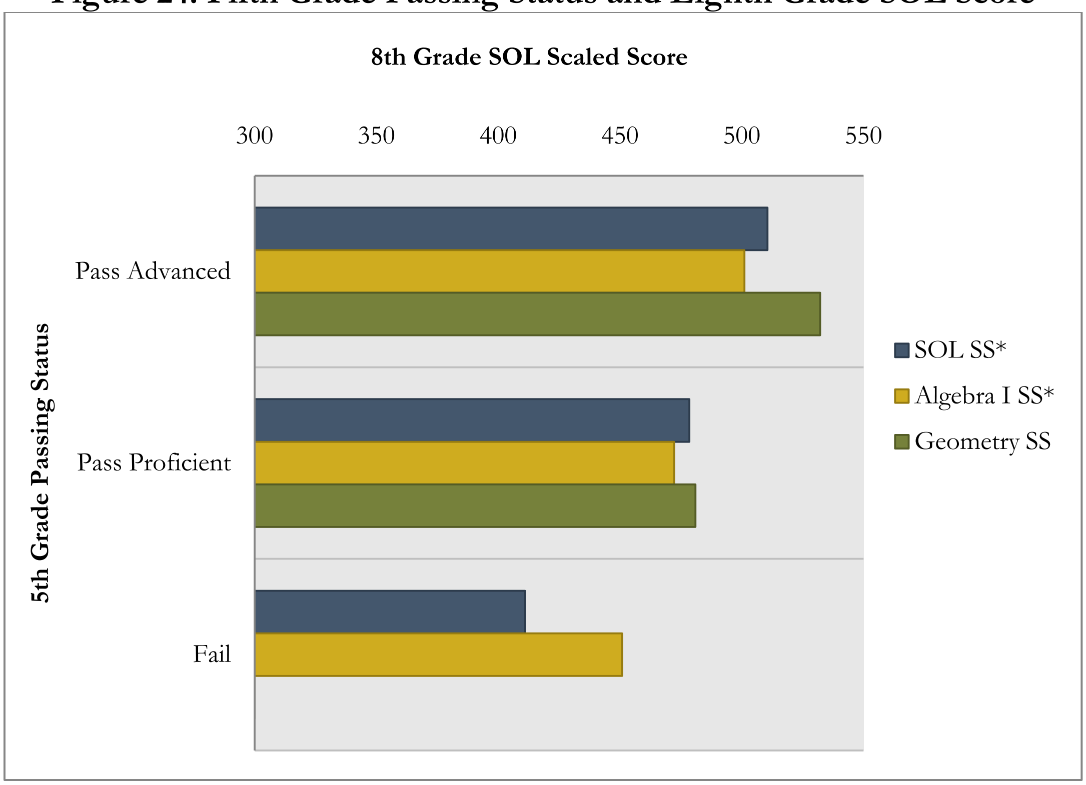
Difference between Fifth Grade Passing Groups in Their Eighth Grade Test Scores

For this question we graphed students' fifth grade passing groups vs. their eighth grade math scaled scores. We excluded Algebra II, since there was only one eighth grade student who took Algebra II. Instead of looking at statistical relationships, we looked at differences in achievement outcomes between Pass Advanced, Pass Proficient and Fail Status fifth graders.

We found the **scores on the eighth grade SOL test and the Algebra I SOL test to be statistically different between the three passing groups**. In other words, Pass Advanced students performed significantly better (on eighth grade SOL and Algebra I SOL) than Pass Proficient students, who in turn performed significantly better than Fail status students.

Though the difference between Pass Advanced and Pass Proficient students appears large for the Geometry scaled score, the difference was not found to be statistically significant. This is because there was only one student who enrolled in Geometry from the fifth grade Pass Proficient group, which led to an unreliable statistical estimate.

Figure 24: Fifth Grade Passing Status and Eighth Grade SOL Score



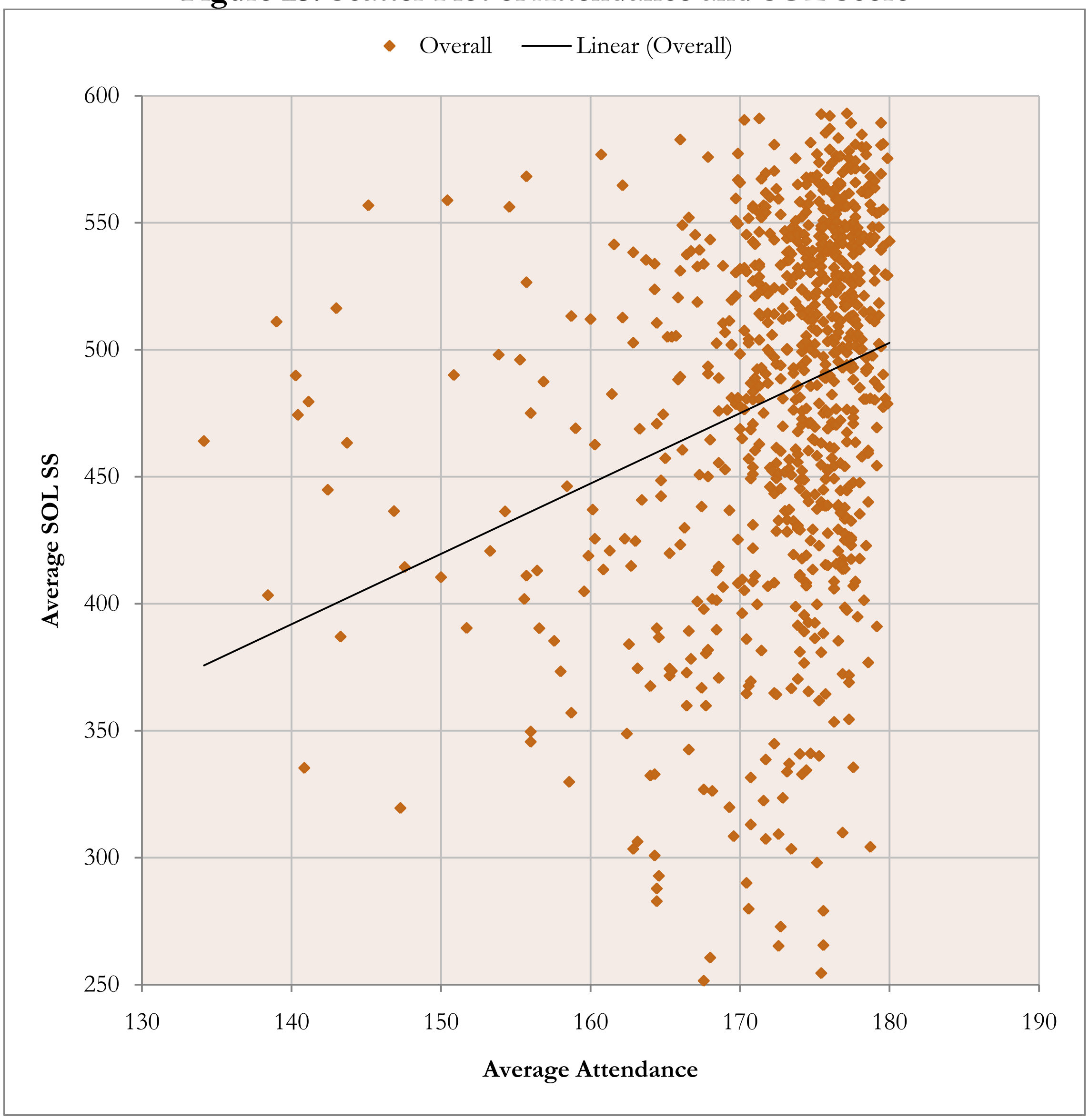
*Differences between Passing Statuses Statistically Significant at $p<0.001$

What is the relationship between days of attendance and test scores among identified groups?

Correlation between Attendance and Test Scores

Figure 25 depicts the overall relationship between attendance and SOL test scores. We essentially calculated the average SOL score for each student across each grade and compared it with their average annual attendance. Based on this graph alone, we can assume that **the correlation between attendance and test score would be low**. This is because there is not enough variation in the attendance measure: The majority of students attended between 170 and 180 days of school a year, on average.

Figure 25: Scatter Plot of Attendance and SOL Score



The table below confirms the above assumption. Half of the correlations are not statistically significant; which means that the level of association is not reliable. Even measures that were found to be statistically significant posted low levels of correlation. Male students have the highest correlation level among the identified groups, signifying that the relationship between attendance and SOL score is the strongest, relatively speaking, among males. Even so, the correlation coefficient is only 0.3 which means the relationship is not strong.

Table 5: Attendance and SOL Score

Student Type	Correlation between Attendance and Overall SOL Scaled Score	Student Type	Correlation between Attendance and Overall SOL Scaled Score
Male	0.306***	Hispanic	0.195***
Overall	0.262***	SPED	0.185
Black	0.234	LEP	0.147
White	0.231***	Asian	0.135
Female	0.230***	Econ. Disadvantaged	0.127

Correlation Statistically Significant at $p<0.01$

We should state one important caveat pertaining to the above analysis. While we were **not able to find a strong relationship between attendance and test scores, we were able to determine that those who had above average attendance tend to perform better** than those who had below average attendance (See Figure 23). This finding is statistically significant for every grade level (See Table 3).

What is the relationship between days of attendance in one school year and math enrollment in the following school year?

Correlation between Past Attendance and Future Enrollment

We once again conducted a correlation analysis to answer the above question. We compared days present from 2005 to 2008 with course category from grade six (2006) to grade nine (2009). The fields in yellow are the correlation coefficients of the relationship between "…days of attendance in one school year" (e.g., *Days Present 2005-06*), and "…math enrollment in the following year" (e.g., *Grade 6 Course Category*).

The correlations below are very low, suggesting there is hardly any association between days of attendance in one school year and the corresponding course enrollment level in the following school year.

Table 6: Past Attendance and Future Enrollment

	Days Present 2005-06	Days Present 2006-07	Days Present 2007-08	Days Present 2008-09
Grade 6 Course Category	0.1021	0.2226	0.2094	0.2443
Grade 7 Course Category	0.0912	0.2449	0.2103	0.2665
Grade 8 Course Category	0.1118	0.2594	0.246	0.2819
Grade 9 Course Category	0.1024	0.2496	0.249	0.2014

Correlation Statistically Significant at $p<0.01$

What other findings does Hanover identify?

Predicting Students' Test Scores

While the above analyses provide insight into the relationship between key variables, they do not provide a model that fully encapsulates why students score differently on standardized tests. To do so it is necessary to conduct an analysis that takes into account all of the factors within one model. To answer this question we conducted a regression analysis that attempts to explain the SOL score for each student (See appendix for note on regression analysis).

From the regression output below, we determined that all but two indicators influence a student's SOL test score. The **two indicators that are not significant are gender and economically disadvantaged status** (see P>|z| for p-value).

The indicators impact test scores differently from one another (see Coefficient sign for +/- values, to determine whether an indicator impacts the SOL test positively or negatively). **LEP and SPED status impacts the SOL test negatively** (i.e., students with these statuses are likely to do poorer than students without these designations). Similarly students taking **summer courses are more likely to score lower** on the test. While female students and economically disadvantaged students tend to score lower on the SOL test than their respective counterparts, these findings are not statistically significant.

Students who have **good attendance records tend to score better** on the SOL test; although the regression coefficient is very small (0.54) compared to that of the other groups. Likewise, students in a **higher course category performed better** on average than students in a lower course category.

In terms of race, we can interpret the findings in relation to black students (the variable that was omitted in the analysis). Based on the regression output, **white, Asian and Hispanic students performed better** on the SOL test relative to black students.

Overall the model is statistically significant (Prob. > chi2 = 0.000). The model explains 44.8 percent of why students scored differently on the SOL (R-sq overall). The model explains 65.7 percent of why groups score differently over time on the SOL test (R-sq between). The model does not explain very well why individuals score differently over time on the SOL test (R-Sq within of 2 percent).

Table 7: Regression Results

Random-effects GLS regression		Number of obs	=	3019
Group variable: id		Number of groups	=	802
R-sq: within	= 0.0223	Obs per group: min	=	1
between	= 0.6572	avg	=	3.8
overall	= 0.4481	max	=	4
Random effects u_i ~ Gaussian		Wald chi2(9)	=	1313.42
corr(u_i, X)	= 0 (assumed)	Prob > chi2	=	0.0000

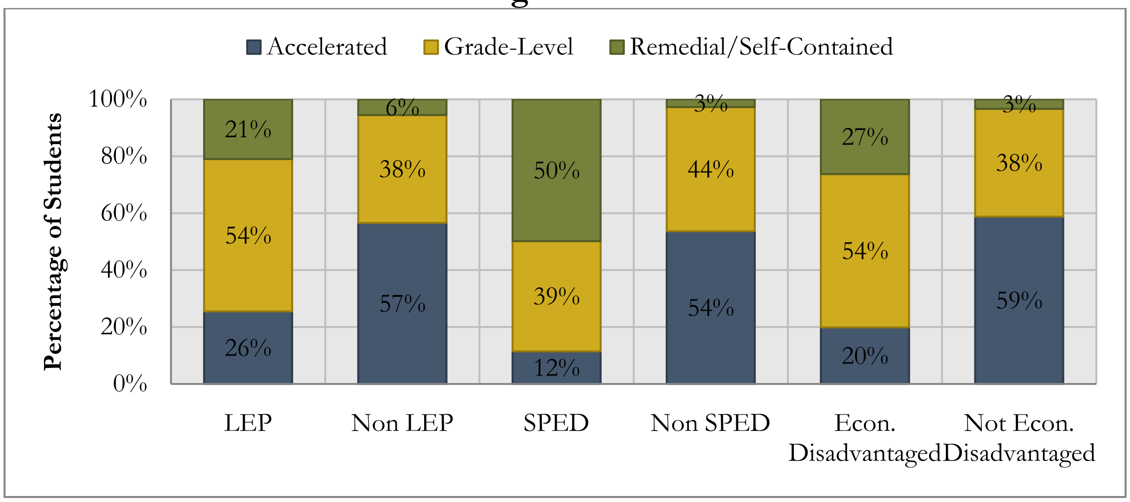
SOL Scaled Score	Coefficient	Standard Error	Z	P>|z|
white	31.74745	5.158526	6.15	0.000
asian	30.90128	6.615786	4.67	0.000
hispanic	22.58993	5.867161	3.85	0.000
female	-3.66546	2.910641	-1.26	0.208
lep	-25.3808	4.150375	-6.12	0.000
sped	-19.2529	5.021941	-3.83	0.000
disadvantaged	-8.82321	4.006734	-2.2	0.028
dayspresent	0.534786	0.150716	3.55	0.000
summercourse	-28.6068	3.958343	-7.23	0.000
coursecategory	23.00851	1.362288	16.89	0.000
_cons	233.1229	27.86846	8.37	0.000

Appendix

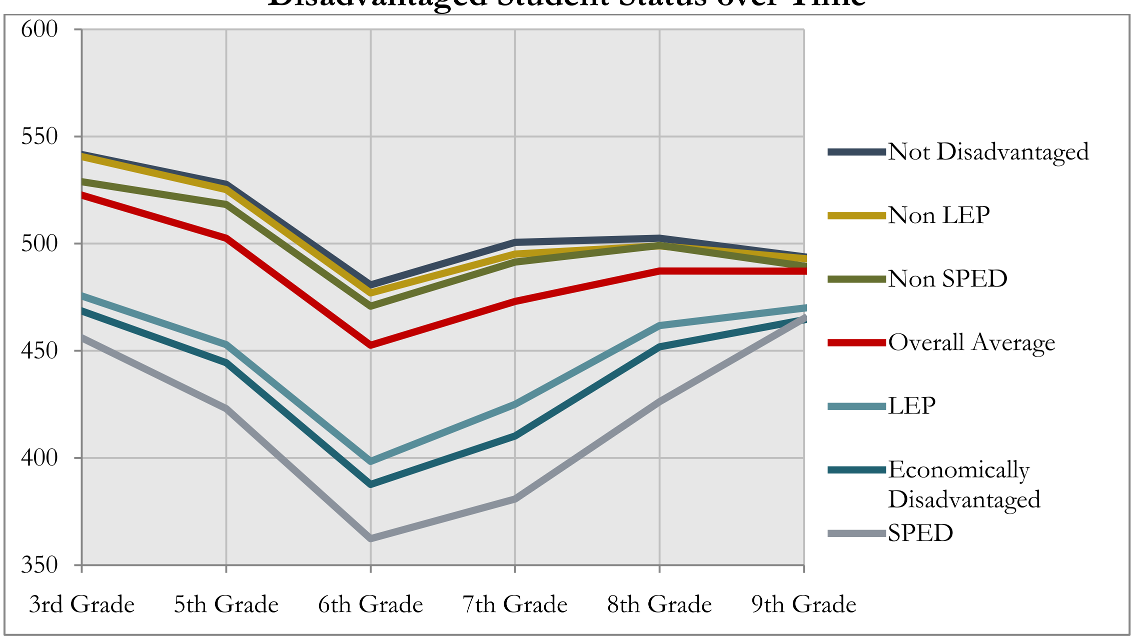
Course Level and Achievement Figures for LEP, SPED, and Economically Disadvantaged Students

The two graphs below provide a summary of the course level breakdown for LEP, SPED, and economically disadvantaged students. The purpose of these graphs is to display the differences between students who were designated these statuses, and students who were not.

Appendix 1: Overall Course Level by LEP, SPED, and Economically Disadvantaged Student Status



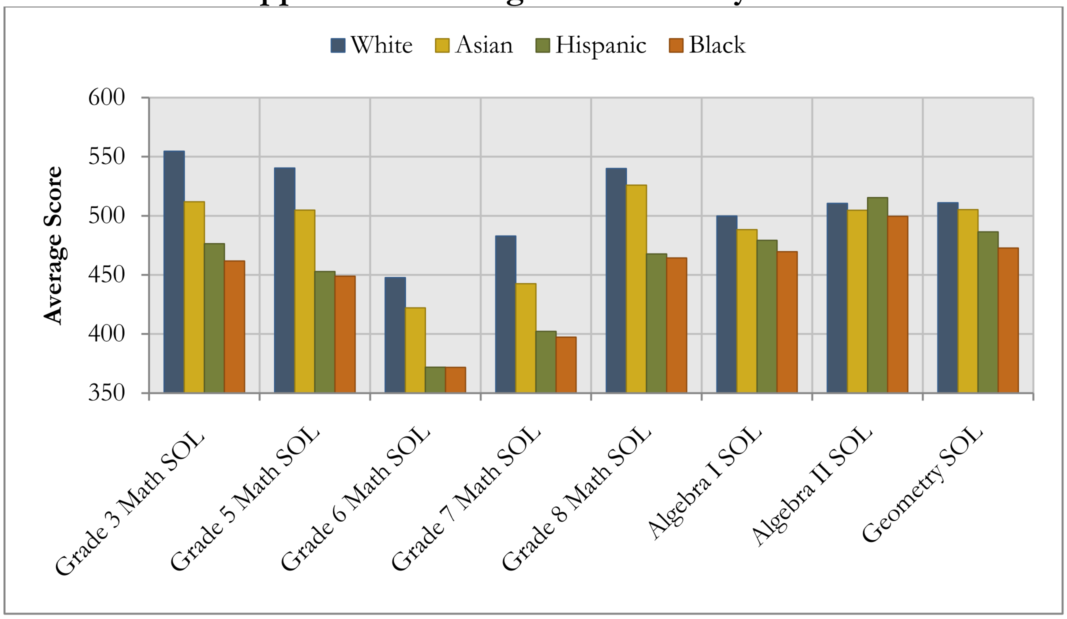
Appendix 2: Average SOL Score by LEP, SPED, and Economically Disadvantaged Student Status over Time



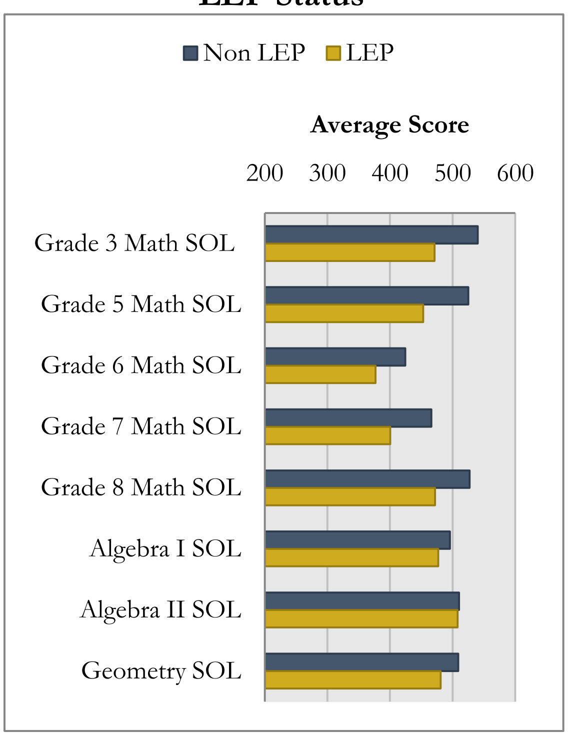
SOL Scaled Score by Student Group

While the analysis in the main body of the report provides findings *based on grade*, the following graphs present SOL test results *based on the test taken*.

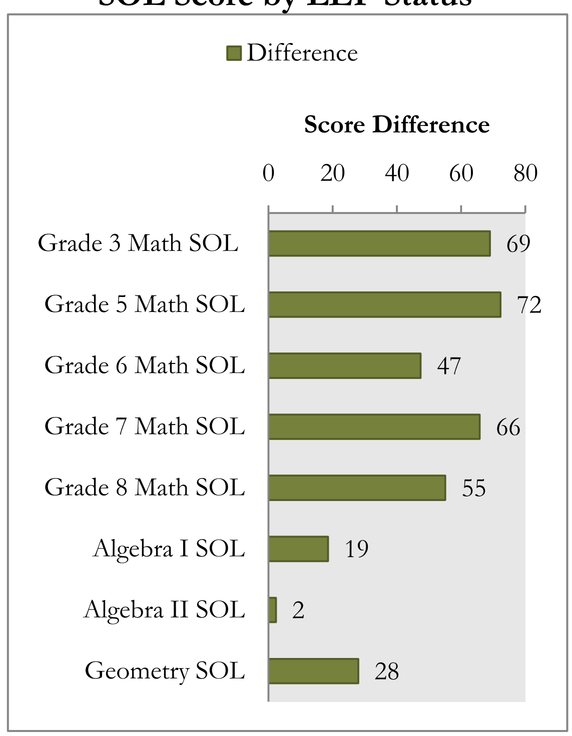
Appendix 3: Average SOL Score by Race



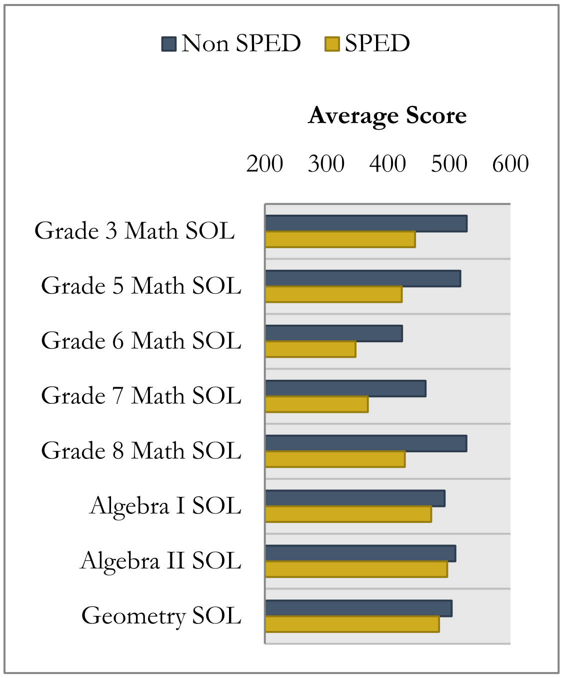
Appendix 4: Average SOL Score by LEP Status



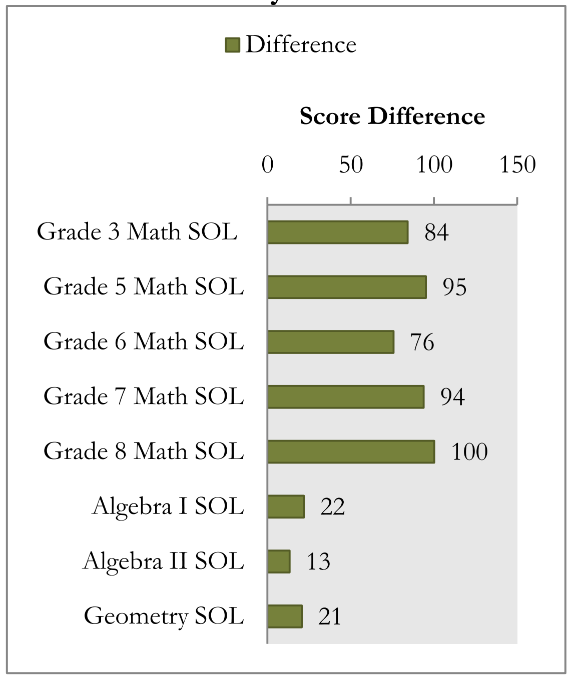
Appendix 5: Difference in Average SOL Score by LEP Status



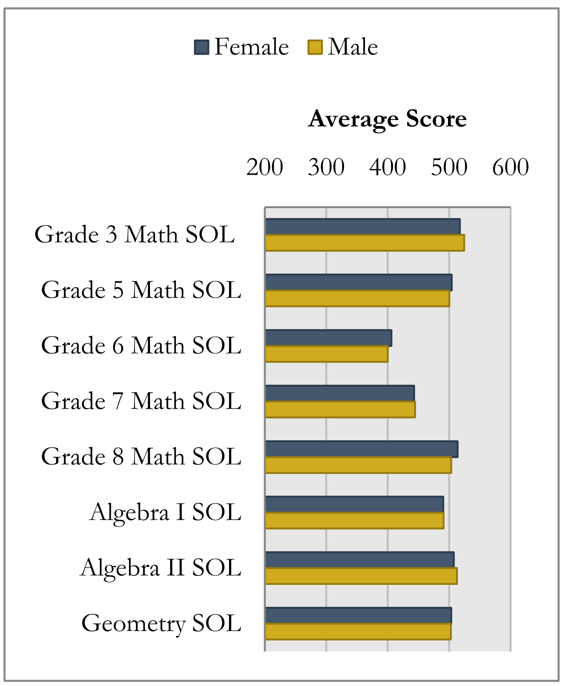
Appendix 6: Average SOL Score by SPED Status



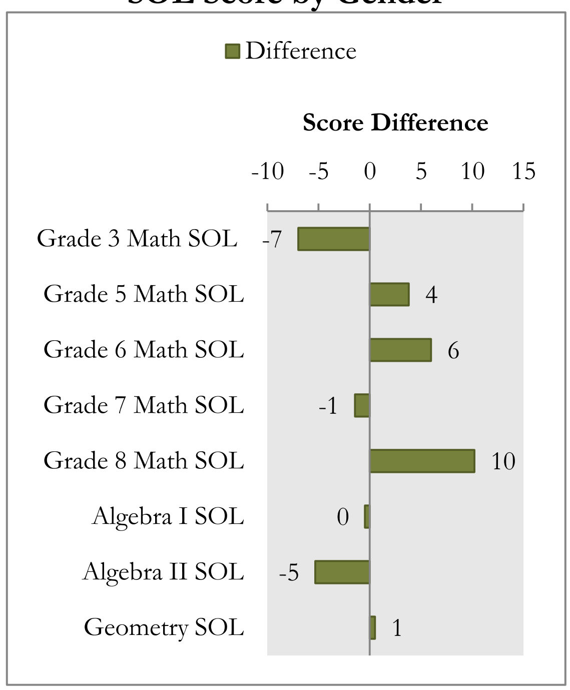
Appendix 7: Difference in Average SOL Score by SPED Status



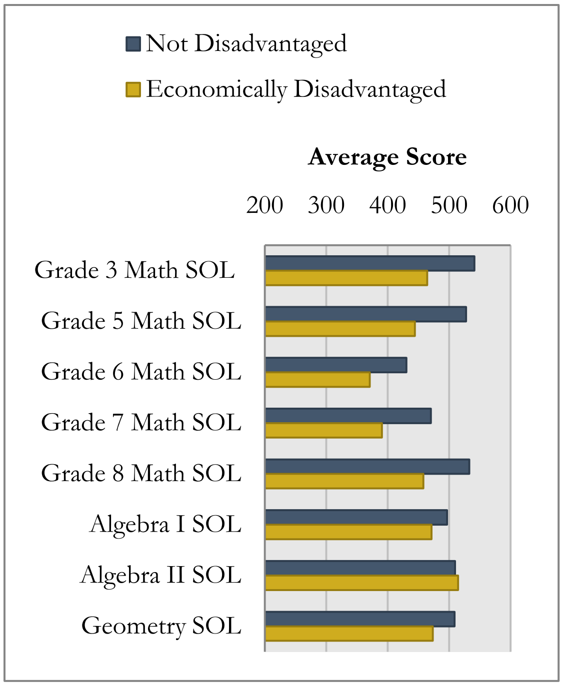
Appendix 8: Average SOL Score by Gender



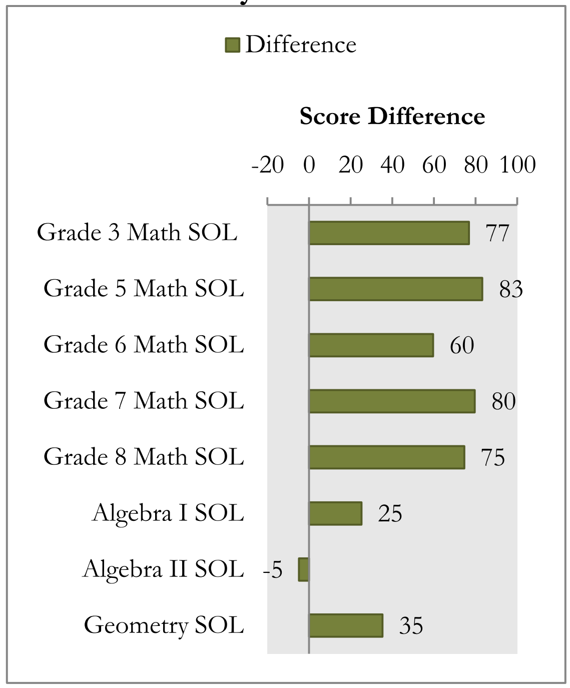
Appendix 9: Difference in Average SOL Score by Gender



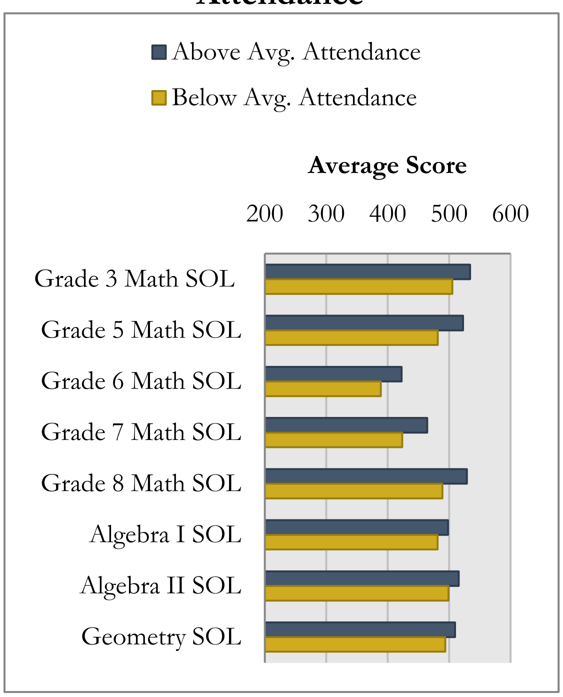
Appendix 10: Average SOL Score by Economic Status



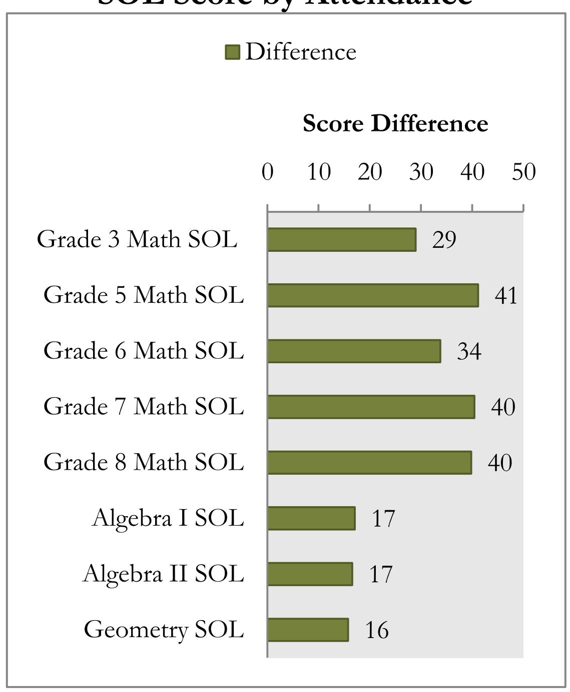
Appendix 11: Difference in Average SOL Score by Economic Status



Appendix 12: Average SOL Score by Attendance



Appendix 13: Difference in Average SOL Score by Attendance



A Note on Correlation Analysis

A correlation analysis measures how closely two indicators are to each other. When one variable *increases* and the other *decreases*, this is considered a negative correlation (e.g. standard of living and poverty). When one variable *increases* and the other *increases* as well, this is called a positive correlation (e.g. standard of living and wealth). When two variables both *decrease* at the same time, this is also called a positive correlation (as long as they are moving in the same direction, correlations are deemed positive).

A perfect positive relationship between two indicators is given the value of 1 and a perfect negative relationship is -1. A value of zero means that there is no relationship whatsoever between two indicators. Correlation does not denote causation. This means that two indicators might be strongly related to each other, but there is no way of telling which one causes the other to increase or decrease.

We consider the correlation between course level and test score a "moderate" and positive correlation. The value of 0.6 is positive because both course level and test score increase in unison. The value is closer to 1 than 0, but the relationship is not as strong as 0.8, for instance, which is why the relationship is considered a moderate one. A value of 0.8 and above would be considered a very strong correlation in social science.

A Note on Regression Analysis

A regression analysis is similar to the correlation analysis. It is a more robust analysis and can be used to predict future relationships. It is usually used when we believe that one variable impacts the other. In this case, we theorize that days of attendance, among other measures, would impact test scores.

In regression analysis, one variable is called the *dependent variable* and the other is called the *independent variable*. An independent variable is a variable that essentially influences the dependent variable. It is possible to include more than one independent variable in the analysis. For our analysis, the dependent variable is SOL Scaled Score and the independent variables are the various race categories, LEP status, SPED status, economically disadvantaged status, gender, course level, and summer course taken. We analyzed how strongly these factors, in unison, impact a student's test score.

The way one interprets the strength of a regression relationship is to look at the R^2 value. Unlike correlation analysis, regression analysis provides a value that is between 0 and 1 (whereas correlation analysis provides a value between -1 and 1). A value of 0 means there is no relationship, and a value of 1 means a perfect relationship between variables. The value can be interpreted as a percentage.

The R^2 measures how much a dependent variable (SOL score) would change based on a change in the independent variable (the various demographic indicators). In our analysis the overall R^2 is 0.45 or 45 percent. This means that these indicators together are responsible for 45 percent of why test scores are different from one student to another. The remaining 55 percent – that may explain why students have different test scores – is unknown. The 55 percent could be from other excluded variables (e.g. a student's household income, the number of hours they spent studying, etc.).

We can interpret whether a relationship is positive, negative or nonexistent, in the regression analysis. To do this we look at the sign of each coefficient in the table. If the coefficient is positive then it means that there is a positive relationship between the demographic measure and the SOL test score (e.g., dayspresent is positive); a coefficient value that is negative means that there is a negative relationship between the two variables (e.g., lep is negative).

The type of regression model that we ran is called a panel regression (random effects model). This is the type of regression that is conducted for longitudinal data. The benefit of this type of regression is that we can determine the changes between groups as well as the changes within an individual over time.

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