Arlington Public Schools

Mathematics Program Evaluation

January 2020

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LIST OF APPENDICES

Appendices, including a detailed program description and evaluation methodology, are available at www.apsva.us/evaluationreports.

EXECUTIVE SUMMARY

Arlington Public Schools (APS) conducts systematic evaluations of instructional programs on a six-year cycle to examine educational progress and ensure continuous improvement in the delivery of its strategic educational goals. This is the third evaluation of the Mathematics Program.

About the Evaluation

The evaluation of the APS Mathematics Program began in 2016-17, during which a planning committee met regularly to develop the questions that would guide data collection. Committee members included staff from Planning and Evaluation, the Mathematics Office, other offices within the Department of Teaching and Learning, Mathematics teachers including Special Education and English Learner teachers, school administrators, and parents. Data for this evaluation was collected over the course of the 2017-18 school year. Important to note is there were certain mathematics pathways studied for this evaluation that APS no longer uses. Prior mathematics pathways allowed students to skip some content while the new pathways compact all mathematical topics in order to ensure students do not miss any mathematics content that is necessary for their future learning.

The evaluation centered on two overarching questions: 1) How effectively was the Mathematics Program implemented and 2) What were the outcomes for the targeted population?

Highlights from this study of the Mathematics Program include:

- Teacher-student interactions demonstrate effective instruction that correlates with best practices and long-term school success.
- APS is providing mathematics instruction that is purposeful and dynamic using relevant data and personalized learning opportunities to adjust and individualize instruction.
- Professional collaboration is happening regularly and contributes to student academic achievement and professional competence.
- There is a high level of student engagement in APS mathematics classrooms. Enrollment in advanced level mathematics courses and some AP classes has been increasing across all demographic categories.
- By the end of Grade 12, almost half of all APS students have taken an advanced or college-level mathematics course.

Mathematics Program

The Mathematics Office provides system-wide leadership for curriculum, professional development, and required mathematics instruction at the elementary, middle, and high school levels. The Mathematics Office serves students in grades K-12, including students enrolled in Advanced Placement, International Baccalaureate, dual enrolled, EL, immersion, and special education courses.

The primary mission of the APS Mathematics Program is to establish and lead a culture of continual learning among teachers toward the implementation of best instructional practices and curriculum design, aligned to division and state goals, in order to challenge students to problem solve and think

for themselves, make real-world connections in order to access future opportunities and build successful lives, and engage in a purposeful community of learning.

Methodology

The APS study uses a variety of informational and data sources to assess program implementation and effectiveness. The Classroom Assessment Scoring System (CLASS), developed at the University of Virginia's Curry School of Education, assesses the interactions between students and adults. The Mathematics Observation Tool, designed by APS Mathematics leadership, evaluates specific areas of content and content delivery used in mathematics classrooms. These two observation tools are complemented by the Mathematics Survey which provides further information about instructional practices and student outcomes and behaviors. A review of mathematics enrollment patterns, presented both as annual measures and within a longitudinal study, conducted for APS by the Hanover Research Council, provides information on the mathematics course trajectories students take over time. An evaluation of standardized testing results at the local, state, and national levels gives important feedback on program efficacy and future needs.

Findings

Instruction

APS mathematics teachers employ best instructional practices in the classroom. They foster a positive learning environment and provide strong classroom organization. Students are receiving individualized instruction based on a variety of formal and informal assessment tools that help guide teacher planning and instructional strategies. Teachers rely primarily on student work and summative assessments to plan and adjust mathematics instruction for the needs of diverse learners.

Teachers indicate they are confident and competent in their knowledge and ability to present mathematical concepts to their students in a variety of modalities as well as to help students connect new learning to prior and future learning. There is regular professional collaboration occurring among mathematics team members, but less frequent collaboration is occurring with English Learner teachers, special educators, and the school resource teacher for the gifted (RTG).

Student engagement in APS classrooms is high. Behavior management and the efficient use of instructional time is observed to be strong at every grade level. Additionally, there is a focus on using clear, precise mathematical language in mathematics classrooms to promote effective communication both by the teachers when they instruct the students and by the students when they verbally demonstrate their understanding of mathematics concepts. A variety of instructional structures and strategies are used at every grade level and opportunities for students to show problem-solving ability are also seen at every grade level. More work is needed around the use of instructional dialog and feedback to students to promote higher-level problem solving and in-depth thinking skills.

Enrollment

Beginning at the earliest grades, assessments are used to ensure students are building the solid foundation of mathematical understanding necessary to progress through a mathematics course sequence that is challenging and appropriate. Preparing all students for success in advanced mathematics coursework and college-level classes is a priority for the Mathematics Office.

Student involvement in advanced and college-level mathematics courses in Grades 11 and 12 can largely be predicted by course enrollment in earlier grades. Enrollment in advanced courses at the middle school level is a good indicator of future participation in advanced and college-level courses in high school.

Enrollment in advanced courses is increasing among all demographic groups; however, there are notable differences in course trajectory pathways between members of different demographic subgroups. Almost 50 percent of APS students graduate high school having taken at least one college-level mathematics course. White, Non-Disadvantaged, Non-SWD (student with no disability) are overrepresented in advanced classes. Disadvantaged, Hispanic, Black, and SWD students are proportionately underrepresented in advanced mathematics courses. EL (English learner) students are also underrepresented. As their English language proficiency level increases so does their participation in advanced coursework.

Efforts continue to encourage and support students to take on the challenge of advanced mathematics coursework as they demonstrate appropriate readiness.

Assessments

Assessment data is consistently used to plan instruction and monitor student progression and enrollment.

In general, APS students are scoring at higher levels than state averages at every grade level in every mathematics course on Virginia Standards of Learning (SOL) assessments. Closer examination reveals, however, that there are many student groups that are passing the SOL at lower rates both at the Proficient and Advanced levels at each grade level. End of Course SOL results over the past five years show that Middle School students have very high pass rates for Algebra I and Geometry, both of which fall in the 95 to 100 percent range. Those pass rates are higher at the Middle School level than at the High School level for students taking those same classes.

The Kindergarten and Grade 1 Assessments indicate that at the earliest levels of education, students are seeing significant and consistent gains in their mathematics aptitude. EL, SWD, and Economically Disadvantaged students also see significant gains. Those gains result in a narrowing of the opportunity gap, but, in general, a 10 percent gap remains between EL, SWD, and Economically Disadvantaged students and their peers.

The Mathematics Inventory (MI) Assessment is a very reliable indicator of student performance and correlates well with other data points. MI results show that specific intervention for students testing below basic grade-level skill readiness has a demonstrable positive impact on performance.

APS AP Pass Rates for Mathematics Courses have been below state and national averages for the past four years. Overall student participation in AP classes has increased though some student groups, such as EL, SWD, and Black students have seen limited or stagnant enrollment.

IB Mathematics Pass Scores from the 2013-14 through the 2017-18 school years have ranged from 80 to 100 percent and generally fall in the mid to upper 90s for each of the three IB Mathematics courses.

Recommendations

Recommendation #1: Provide growth and leadership opportunities by providing meaningful, high-quality, and relevant professional learning opportunities to support retaining and advancing high-quality employees.

- Continue to strengthen teacher content knowledge through job-embedded professional development provided by mathematics coaches, APS Content Academies, and university partnerships
- Strengthen the utilization of best practices through professional learning around
    - Mathematics Workshop
    - Content academies
    - Principal Institutes
    - Mathematics coaching
    - Lead Teacher & Department Chair development
    - Secondary Mathematics countywide learning opportunities
- Co-teaching in collaboration with the Office of English Learners, the Office of Special Education, and the Office of Gifted Services
- Create a universal professional learning plan for teachers, coaches, and administrators
- In collaboration with the Office of English Learners and the Office of Special Education, encourage mathematics teaching staff to earn educational credits and/or an endorsement in the areas of English Learner Education and Special Education to improve teaching pedagogical practices for all students
- Support teachers and coaches working toward Mathematics Specialist endorsements

Recommendation #2: Allocate staffing for more Mathematics Coaches at the elementary and high school levels and sustain allocations at the middle school level. Mathematics Coaches work to

- Improve student achievement and address the opportunity gap through the improvement of instruction
- Work with administrators, teachers, students, parents and the community toward meeting APS mathematics goals
- Support the self-directedness of individual teachers and/or teams of teachers through coaching, consulting, and collaborating

- Assist teachers in interpreting data and with incorporating strategies to improve student achievement and instruction
- Promote teachers' delivery and understanding of the curriculum through collaborative long-range and short-range planning
- Facilitate teachers' use of successful, research-based instructional strategies, including differentiated instruction for diverse learners
- Meet regularly with school administration to review data and plan
- Collect data through observation of instruction to support teachers in planning and reflecting
- Engage in research-based professional development and applies learned professional development practices
- Assist in development of curriculum and assessment resources
- Prepare and delivers staff development related to APS Mathematics Office
- Support the work of the school's leadership team by representing the mathematics lens and advocating for high quality instructional practices
- Engage in his/her own learning and planning to prepare for support of teachers and teams
- Promote equitable teaching practices

Recommendation #3: Develop curriculum guides and documents that integrate instructional approaches focused on improving student achievement in all demographic groups, in collaboration with other Teaching and Learning Offices, such as Gifted, English Learner, Special Education, Personalized Learning, and the Arlington Tiered System of Support to

- Provide research-based curricular materials aligned to current standards
- Deploy research-based interventions and curricular support for targeted groups such as English learners, students with disabilities, and students above or below grade level
- Offer professional learning to promote personalized learning opportunities in the classroom
- Provide opportunities that support teacher with depth and complexity in instruction
- Provide intentional opportunities for students to read, write, speak, and listen within curriculum documents and resources

Recommendation #4: Provide multiple pathways for success to all students by creating access to advanced and college level courses in a variety of ways.

- Design a flexible Mathematics Program that includes modules, course options, and courses with a compacted curriculum which allow students to demonstrate readiness for college level classes or advanced coursework at their own pace
- Create a comprehensive vertical articulation that leads to increased depth and complexity at the elementary level with the goal of comprehensively preparing students for more rigorous middle school coursework

- Create a comprehensive vertical articulation that leads to increased depth and complexity at the middle school level with the goal of comprehensively preparing students for more rigorous high school coursework
- Explore additional ways to compact high school course material
- Utilize technology to augment instruction and support access to advanced mathematics courses
- Work with all stakeholder groups to ensure common understanding of the role of additional depth and complexity and course progressions, including
    - Students
    - Families
    - Teachers
    - Directors of Counseling and Counselors
    - Administrators

SECTION 1: FINDINGS

Evaluation Question #1: How effectively was the Mathematics Program implemented?

To address this question, the evaluation focused on four areas: quality of instruction, student access, teacher preparation, and use of resources.

QUALITY OF INSTRUCTION

Classroom Observations

Systematic observations provide a snapshot of descriptive information about instructional best practices and curriculum alignment occurring in APS classrooms. APS staff can use the results to identify strengths and areas of need and to direct resources towards improving practices that are shown to positively impact student learning.

This evaluation includes two types of observations. The Classroom Assessment Scoring System TM (CLASS) observes and measures the effectiveness of teacher-student interactions. CLASS research shows that a well-managed classroom with emotional and instructional support promotes long-term school success across Grades PK–12. The Mathematics Observation Tool protocol for observations identifies classroom instruction that aligns with the APS mathematics curriculum and best practices.

Classroom Assessment Scoring System

Arlington Public Schools uses the Classroom Assessment Scoring System (CLASS) observation tool to assess the quality of interactions between teachers and students for all program evaluation areas. It was developed by the University of Virginia's Curry School of Education as an early childhood observation tool, and later expanded to include other grade levels. CLASS observations examine student-teacher interactions and measure the effectiveness of those interactions to promote academic learning, engagement, and social development. Results help to determine mathematics program strengths and weaknesses and opportunities for professional development.

The CLASS tool organizes teacher-student interactions into three broad domains: **Emotional Support**, **Classroom Organization**, and **Instructional Support**. The upper elementary (grades 4–5) and secondary tool include a fourth domain: **Student Engagement**. Dimensions are scored on a 7-point scale consisting of Low (1, 2), Mid (3, 4, 5), and High (6, 7) ranges.

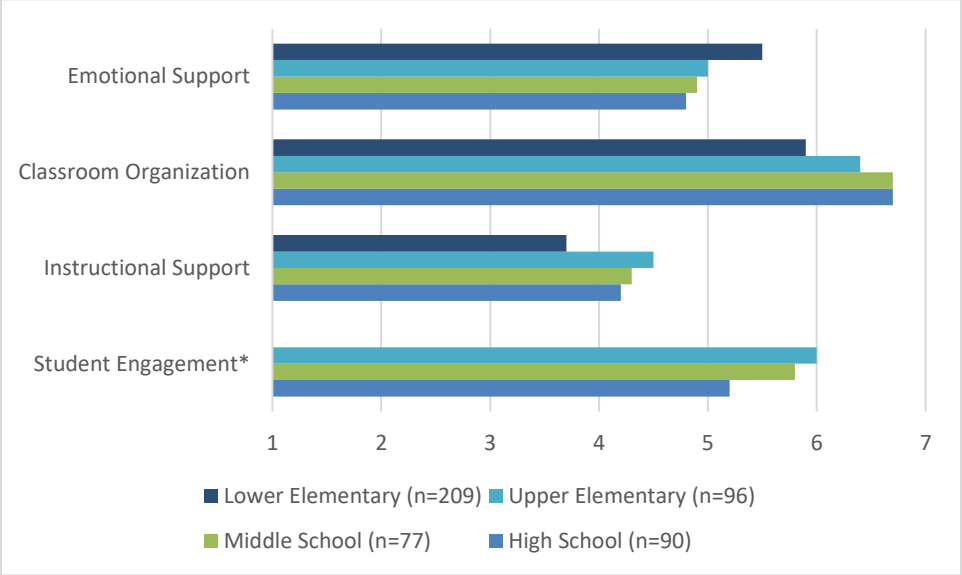
CLASS observations were conducted in mathematics classes (including EL and Special Education) throughout the 2017-18 school year at all grade levels. Observers conducted one 30-minute observation for each observed teacher. Table 1 shows the percentage of teachers observed by level.

Table 1: Number of CLASS Observations by Level

Teacher Group	Total Number of Teachers	Number of Teachers Observed	Percentage of Teachers Observed	Margin of Error (95% Confidence Level)
Elementary School Teachers	935	305	33%	4.6%
Secondary Middle School Teachers	93	77	83%	4.7%
Secondary High School Teachers	88	75	85%	4.4%

At each grade level, average Mathematics CLASS domain scores fall into the high-mid or high range for **Emotional Support** and **Classroom Organization**. Average **Student Engagement** scores are also in the high-mid to high range across grade levels. Similar to national and APS district-wide trends, the average **Instructional Support** scores are lower and fall into the mid range.

Figure 1: Average CLASS Domain Scores by Level



(When interpreting CLASS results, Teachstone advises that typically, half a point to a point difference is considered to be **educationally significant**; in other words, a difference that would impact outcomes for students[1].)

Emotional Support refers to teacher behaviors that promote students' academic achievement and engagement by fostering positive relationships and motivation. Specifically, in the areas of Positive Climate and Teacher Sensitivity, average scores fall in the mid-high range. Regard for Student

[1] Teachstone, personal communication, June 13, 2014 and January 5, 2016

Perspectives average scores are all in the average to low average range with a slight trend downward as grade level increases with a low of 3.1 at the High School Level.

Classroom Organization describes effective classroom structure and time management. The highest CLASS mean scores are in the area of Classroom Management. There is an increase in mean scores from a high-mid score of 5.9 at the Lower Elementary Level to a high mean score of 6.7 at both the Middle and High School Levels. Behavior Management and Productivity mean scores within that domain reflect similar scores and upward trends.

Instructional Support refers to specific teaching behaviors that push students' thinking and lead to deeper understanding and more advanced performance skills. Average domain CLASS scores for each grade level are the lowest in this area. There are consistent patterns across grade levels in regards to the dimension scores within the Instructional Support domain. In the areas of Instructional Learning Formats and Content Understanding mean scores were uniformly in the high-mid range. In the areas of Quality of Feedback and Instructional Dialogue, mean scores were average. For all grade levels, Analysis and Inquiry mean scores were the lowest trending down from a 3.7 at the Upper Elementary level to a low of 2.6 at the Middle and High School Secondary levels.

Table 2: Average Domain and Dimension Chart

Dimension/Domain	Level	Elementary			Middle School			High School		
		N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Emotional Support	K-12	305	5.3	0.7	77	4.9	1.0	75	4.8	0.7
Positive Climate	K-12	305	5.3	0.9	77	5.5	1.2	75	5.5	0.9
Negative Climate[2]	K-3	209	1.0	0.2						
Teacher Sensitivity	K-12	305	5.6	0.9	77	5.7	1.2	75	5.9	0.9
Regard for Student Perspectives	K-5	305	4.1	1.0						
Regard for Adolescent Perspectives	6-12				77	3.4	1.0	75	3.1	0.9
Classroom Organization	K-12	305	6.0	0.7	77	6.7	0.5	75	6.7	0.5
Behavior Management	K-12	305	5.9	0.9	77	6.5	0.8	75	6.5	0.9
Productivity	K-12	305	6.0	0.8	77	6.6	0.7	75	6.5	0.6
Instructional Learning Formats	K-3	209	5.7	0.8						
Negative Climate	4-12	96	1.0	0.2	77	1.1	0.3	75	1.1	0.3
Instructional Support	K-12	305	4.0	0.9	77	4.3	0.9	75	4.2	0.7
Concept Development	K-3	209	3.4	1.0						
Quality of Feedback	K-12	305	5.3	0.7	77	4.0	1.2	75	4.5	0.9
Language Modeling	K-3	209	3.8	1.1						

[2] A lower score is desirable for the Negative Climate Dimension. The Negative Climate score is reversed when calculating the Classroom Organization Domain score.

Instructional Learning Formats	4-12	96	5.6	0.8	77	5.4	0.9	75	5.2	0.7
Content Understanding	4-12	96	4.8	1.1	77	5.3	1.2	75	4.9	1.1
Analysis and Inquiry	4-12	96	3.7	1.2	77	2.6	0.8	75	2.6	1.0
Instructional Dialogue	4-12	96	4.3	1.2	77	4.2	1.4	75	4.0	1.2
Student Engagement*	4-12	96	6.0	0.7	77	5.8	1.0	75	5.2	0.8

*The Student Engagement domain is not included in the lower elementary CLASS tool.

- Elementary School specifics: Classroom Management has a very high mean score of 6.0 and its component dimensions of Behavior Management, Productivity, and Instructional Formats reflect equally high mean scores. Student Engagement is also an area of strength with a high mean score of 6.0. The Instructional Support mean score of 4.0 was the lowest mean domain score at the elementary level. Though Instructional Learning Formats and Quality of Feedback average scores are in the high mid-range, low mid-range scores in the areas of Concept Development (3.4), Analysis and Inquiry (3.7), and Language Modeling (3.8) bring the overall domain score down significantly.
- Middle School specifics: Classroom Management has a very high mean score of 6.7 and high mean scores for its component dimensions as well. Student Engagement is another area of strength with a mean score of 5.8. Instructional Support is observed to have the lowest mean score for this grade level with a 4.3. Disparity among its dimension scores and a very low mean score of 2.6 in the area of Analysis and Inquiry has a negative impact on the overall domain score.
- High School specifics: Classroom Management has a very high mean score of 6.7. Student Engagement is slightly lower than the other grade levels, but falls in the high mid-range at 5.2. The Instructional Support Domain, with a mean score of 4.2, is the lowest score at the high school level. A mean score of 2.6 in the area of Analysis and Inquiry brings down the overall domain score.

Table 3, below, describes the Indicators and Behavioral Markers associated with the Analysis and Inquiry dimension. Teachers in classrooms with effective analysis and inquiry give students opportunities to develop higher-level thinking skills. This helps students to become analytical and creative thinkers.

Table 3: Indicators and Behavioral Markers Associated with Analysis and Inquiry

Facilitation of higher-order thinking	Opportunities for novel application	Metacognition
• Students identify and investigate problems/questions • Students examine, analyze, and/or interpret data, information, approaches, etc. • Students construct alternatives, predict, hypothesize, or brainstorm • Students develop arguments, provide explanations	• Open-ended tasks • Presents cognitive challenges • Students apply previous knowledge/skills	• Students explain their own cognitive processes • Students self-evaluate • Students reflect • Students plan • Teacher models thinking about thinking

Summary of CLASS scores

Overall CLASS scores show that APS mathematics teachers have very strong Classroom Organizational skills. These skills translate to clear behavioral expectations and efficient use of instructional time. APS mathematics teachers also demonstrate strong skills in the area of Emotional Support. These skills indicate teacher responsiveness to the academic and developmental needs of individual students and the entire class. The high scores seen in the area of Student Engagement capture the degree to which all students are focused and participating in the learning activity facilitated by the teacher.

Lower CLASS scores in the area of Instructional Support indicate a need for the APS Mathematics Office to strengthen skills in this area. High mid-range mean scores in the areas of Instructional Learning Formats and Content Understanding reveal that lesson objectives are clear and engaging, however, consistently low scores in the area of Analysis and Inquiry show that the development of higher-level thinking skills such as analysis, problem-solving, and reasoning were not consistently observed. Average scores in the areas of Quality of Feedback and Instructional Dialogue also demonstrate a need for continued improvement. Enhancing the quality of feedback can expand and extend learning and understanding as well as encourage student participation. Encouraging dialogues that are meaningfully connected to lesson content promotes in-depth learning.

Further information about the CLASS observation tool, including its domains and dimensions, can be found in Appendices B1 and B2. The full report on CLASS scores from the 2017-18 mathematics observations can be found in Appendix B3.

Mathematics Observation Tool

The Mathematics Observation Tool was developed by the Mathematics Office to assess the teaching structure, content, and strategies being used in the APS Mathematics classroom. By designing its own observation tool, the office is able to focus on the specific classroom practices it wants to evaluate and measure. Particular attention is focused on mathematics discourse in the classroom, the way students manifest their understanding of mathematics concepts, and the use of technology. It is used as an assessment tool to provide information about the mathematics program's effectiveness in its delivery of mathematics instruction and differentiation of that instruction.

Table 4: Total Number of Mathematics Observations

Teacher Group	Number of Teachers	Number of Observations	Percent Observed	Margin of Error (95% Confidence Level)
Elementary Teachers	935	265	28%	5.1%
Middle School Teachers	93	69	74%	6.0%
High School Teachers	88	64	73%	6.4%

According to the Mathematics Observation Tool results, classroom lesson objectives are in almost 100% alignment with the APS Mathematics Curriculum. The APS Mathematics Curriculum is aligned with division and state curricula which strive to implement best instructional practices and curriculum design to challenge students to use the tools of mathematics to problem-solve and think for themselves as well as to engage in a purposeful community of learning.

Table 5: Lesson Objective Aligned with Curriculum

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
The objective is aligned with the curriculum	99%	91%	98%
Objectives have no connection to the curriculum-there are objectives for class but they are not related to the curriculum	0%	0%	0%
Unsure	1%	9%	2%

Several questions from the Mathematics Observation Tool are concerned with content instruction. Ratings were based on a four-point scale, with 1 indicating that there is no evidence of the connection and 4 indicating that the evidence is exemplary. Figures 2 – 4 show the responses to these content observation areas by grade level.

Students connect what they learn to what they already know by linking new information to their existing knowledge. Overall, evidence of acceptable or exemplary connection was seen on average as follows:

- At the Elementary School level, connections are made between previous learning and new learning in over 90 percent of the classrooms. This is consistent with the 2012 Mathematics Evaluation report findings.
- At the Middle School level, connections are observed in 86 percent of classrooms - an increase of 15 points from the 2012 results.
- At the High School level, connections between previous and new learning occur in 91 percent of classrooms - a dramatic increase from the 2012 report with results reported at 46 percent.

The mathematics content presented by the teacher was accurate.

- One hundred percent of the elementary observations showed accurate content, an increase of 3 percentage points from the prior report.
- Ninety-nine percent of observations at the middle school level showed accurate content - a rise of 5 percentage points.
- Ninety-seven percent of high school observations demonstrated accurate content, up almost 10 percentage points from the 2012 report with results reported at an 88 percent.

The graphs also provide information concerning teacher and student use of precise and accurate mathematical language and vocabulary. These observations help ascertain the ability of the teacher to communicate concepts clearly, provide feedback effectively, as well as promote the use of mathematical language in the classroom through the modeling of grade-level mathematical language. Additionally, observations of students' ability to explain their thinking using appropriate grade-level mathematical language is an indicator of teacher success in using precise and accurate mathematical language and vocabulary.

For all grade levels, teacher use of precise and accurate mathematical language and vocabulary appropriate to the grade level is at or near 100 percent. This is an increase at every level, but in particular at the middle and high school levels where prior scores were 88 percent and 77 percent respectively.

Mathematical classroom discourse pertains to discussions in which students engage in discussions about mathematics which makes visible their mathematical thinking as well as increases their understanding of concepts. Students also learn to engage in mathematical reasoning and debate. Discourse can be used to determine what students are thinking and understanding in order to build bridges between what they already know and what there is to learn; and it can offer opportunities to develop agreed-upon mathematical meanings or definitions and explore conjectures.

Teachers use questioning strategies to encourage classroom dialogue and to provide opportunities for students to utilize new mathematics vocabulary and demonstrate their understanding of mathematics concepts. Importantly, when teachers provide adequate wait time, they allow time for students to reflect before answering which encourages thoughtful responses.

Scores reflect the combined score of Acceptable and Exemplary ratings. In general, these strategies trend down as grade level increases.

- Elementary school observations show that teachers use questioning strategies in 78 percent of the classrooms and provide adequate wait time in 77 percent of the classrooms.

- Middle school observations show that teachers use questioning strategies in 71 percent of the classrooms and provide adequate wait time in 65 percent of the classrooms.
- High school observations show that teachers use questioning strategies in 60 percent of the classrooms and provide adequate wait time in 52 percent of the classrooms.

Figure 2: Elementary School Mathematics Observations of Content Instruction

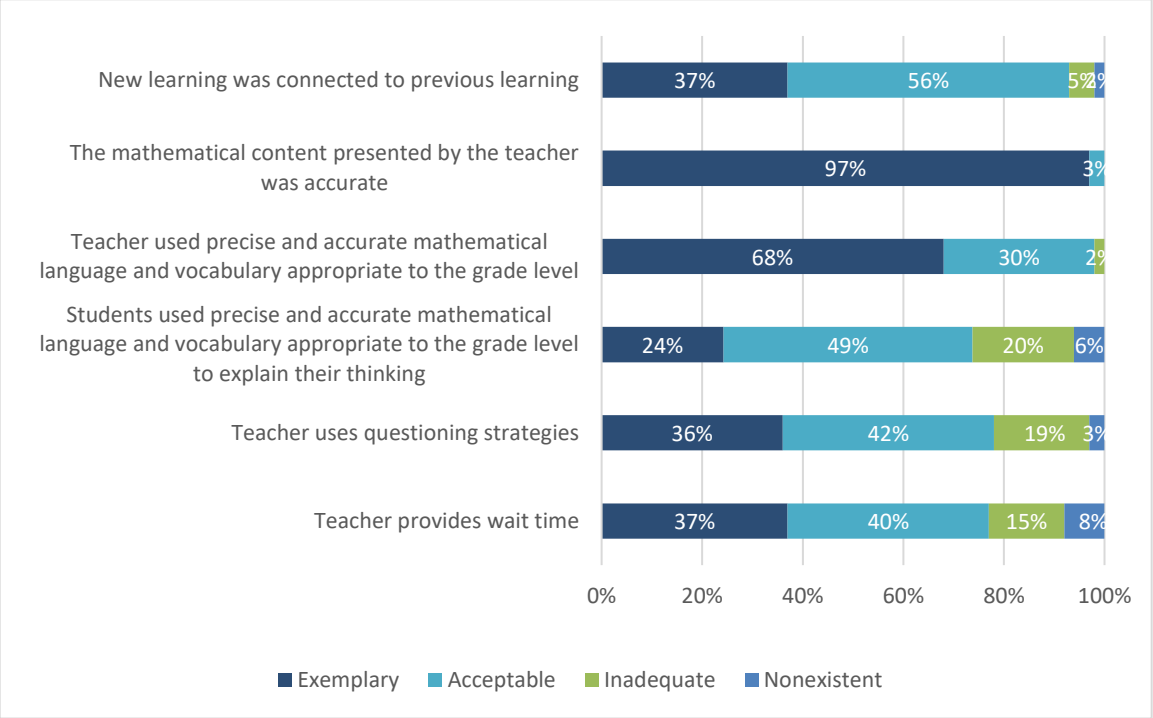


Figure 3: Middle School Mathematics Observations of Content Instruction

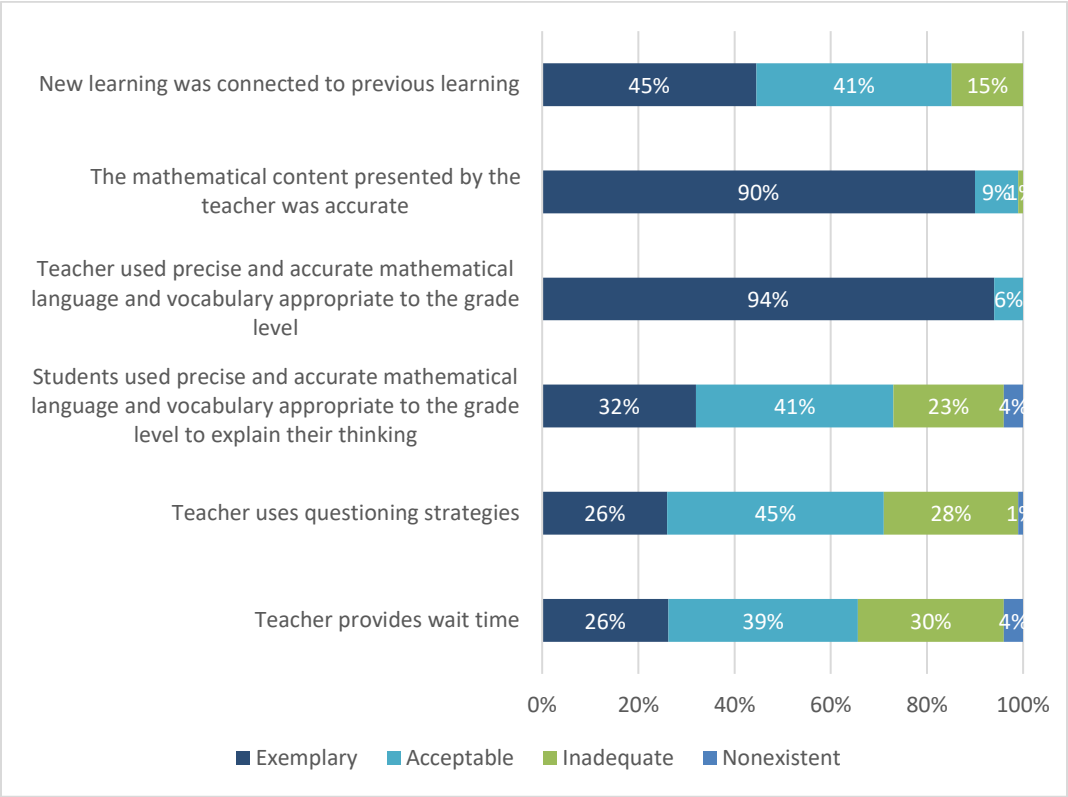
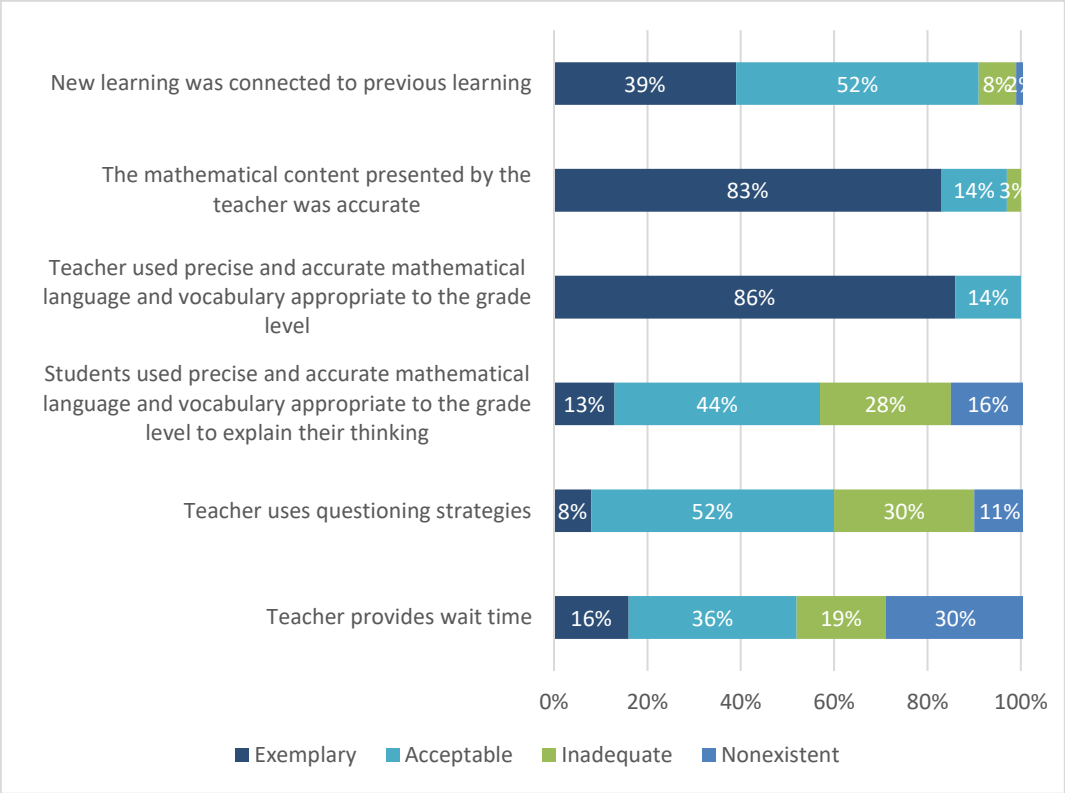


Figure 4: High School Mathematics Observations of Content Instruction



From Table 6, observations demonstrate that a wide variety of instructional structures are used in mathematics classrooms at all grade levels which provide opportunities for students to engage with mathematics and demonstrate their understanding in multiple ways. The workshop model of instruction develops mathematics knowledge and communication skills through these personalized learning opportunities and options. In addition, teachers are able to use dynamic student grouping to differentiate instruction in the classroom to best meet the needs of all students.

- The most commonly observed instructional structures being used in the elementary classroom are Directions/Instructions, Guided Practice, and Pair or Group Work, at 61, 56, and 50 percent respectively. Lecture and Self-evaluation at three percent, and Reflection and Closure at two percent were the least commonly observed. Mini Lessons, Number Sense Routines, and Cooperative Learning are observed much more frequently at the elementary level as compared to the other grade levels.
- The most commonly observed instructional structure being used in the middle school classroom is Directions/Instructions at 80 percent, 15 percent higher than the next most commonly observed structure, Guided Practice, at 65 percent; followed by Independent Seatwork at 58 percent. Inquiry-Based or Discovery Learning is seen the most frequently in middle school classrooms. Number Sense Routines and Cooperative Learning are observed the least at the middle school level as compared to other grade levels.

- The most commonly observed instructional structure being observed in the high school classroom is Guided Practice at 84 percent, followed by Directions/Instructions at 64 percent, and then Independent Seatwork at 59 percent. Lecture and Problems in Context are observed most frequently in high school classrooms. Self-evaluation, Reflection, and Closure are not observed at all at the high school level.
- Learning stations and Hands on Experiments are observed more often in elementary and middle school.
- Across grade levels Self-evaluation, Reflection, and Closure are observed infrequently or not at all.

Table 6: Instructional Structures Included in the Lesson

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
Inquiry-based or discovery learning	11%	39%	23%
Lecture	3%	4%	22%
Guided practice	56%	65%	84%
Guided discussion	32%	49%	50%
Pair or Group work	50%	46%	31%
Mini lesson	46%	28%	22%
Independent Practice	29%	29%	23%
Number sense routines	45%	9%	23%
Learning stations	29%	12%	3%
Cooperative Learning	33%	23%	30%
Hands-on/ Experiments/Labs	23%	20%	5%
Directions/Instructions	61%	80%	64%
Self-Evaluation	3%	3%	0%
Reflection	2%	1%	0%
Independent Seatwork	41%	58%	59%
Summarizing	13%	9%	9%
Formative assessment	9%	6%	2%
Problems in context	18%	22%	28%
Closure	2%	4%	0%

Tables 7 & 8 evaluate the mathematics classroom task complexity and the cognitive complexity demonstrated by the students. The six educational objectives listed on these tables (Remember, Understand, Apply, Analyze, Evaluate, and Create) are from Bloom's Taxonomy, a hierarchical model of cognitive functioning used by educators to guide instructional objectives, assessments, and activities.

- The cognitive complexity of the tasks at the Elementary level are primarily in the Remember, Understand, and Apply levels where skill development is focused on acquiring knowledge, demonstrating that knowledge and problem-solving using that knowledge.
- At Middle School and High School levels, progressively higher-level cognitive tasks are observed. The number of observations of cognitive complexity involving analytical and evaluative thinking skills did increase as the grade level increased.

- No observations of tasks involving creative thinking were seen at the high school level.

Table 7: Cognitive Complexity of Task/Assignment

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
Remember	100%	99%	100%
Understand	97%	100%	100%
Apply	66%	88%	95%
Analyze	15%	49%	55%
Evaluate	2%	15%	28%
Create	2%	9%	0%

Table 8: Cognitive Complexity Demonstrated by the Student

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
Remember	100%	100%	100%
Understand	96%	97%	100%
Apply	59%	84%	92%
Analyze	12%	39%	33%
Evaluate	2%	16%	22%
Create	1%	6%	0%

As shown in Table 9, students at all grade levels demonstrate problem-solving skills through varied approaches both independently and collaboratively.

Table 9: Problem-Solving Behaviors Demonstrated by Students

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
Collaborate with others	51%	45%	53%
Use varied/appropriate strategies	47%	28%	22%
Construct and discover ideas	27%	19%	3%
Make multiple attempts, if needed	64%	68%	92%
None	10%	6%	3%

According to Table 10, students have opportunities to demonstrate verbal mathematical communication skills in a variety of ways. At the elementary and middle school levels, students most commonly demonstrated mathematics communication behavior by explaining their thinking.

- Elementary school students have an even distribution of other ways they demonstrate communication behaviors. Turn and talk behavior and adding on to what others say were both observed in 26 percent of those classrooms. In 12 percent of elementary classrooms, there was no demonstration of mathematical communication behaviors observed.
- The ways middle school students demonstrate verbal mathematical communication skills beyond explaining their thinking include an almost equal amount of time discussing problem-solving approaches (29 percent), asking for clarification (25 percent), and turn and talk (25 percent). In 10 percent of those classrooms, there is no demonstration of mathematical communication behaviors observed.

- High school students have wider variation in the ways they demonstrate mathematical communication behaviors than seen at other grade levels. The most commonly demonstrated behavior is asking for clarification at 56 percent, followed by explaining their thinking at 41 percent and turn and talk behavior at 28 percent. In 8 percent of high school classrooms, there is no demonstration of mathematical communication behaviors observed.

Table 10: Mathematics Communication Behaviors Demonstrated by Students

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
Turn and Talk	26%	25%	28%
Explain their thinking	66%	59%	41%
Repeat/Rephrase another student	13%	4%	5%
Ask for clarification	24%	25%	56%
Add on to others	26%	16%	9%
Agree/Disagree and state why	21%	22%	14%
Share/Discuss approaches or ways to solve problem	20%	29%	23%
None	12%	10%	8%

According to Table 11, students have opportunities in the classroom to demonstrate their thinking, not only verbally, but also by using mathematical representations to communicate their ideas. Representation is a process standard given by the National Council of Teachers of Mathematics and is also one of the process goals in the VDOE Mathematics Standards that all Virginia mathematics teachers are required to teach. These representations include the use of numbers or symbols; drawing or picture; concrete material; digital manipulatives; tables, charts and/or graphs.

In 100 percent of classrooms, across all grade levels, students successfully demonstrate their mathematical thinking using representations. Use of numbers and symbols is the most commonly observed way students demonstrate their thinking utilizing representations. Drawing or Picture is the next most commonly observed way students demonstrate their thinking. The use of Digital Manipulatives is the least commonly observed way students utilize representations to demonstrate thinking across grade levels.

Table 11: Representations Utilized by Students to Demonstrate their Thinking

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
Numbers and/or symbols	80%	94%	100%
Drawing or picture	56%	46%	45%
Concrete material	48%	20%	11%
Digital manipulatives	9%	9%	6%
Tables, chart, and/or graph	15%	17%	13%
None	Less than 1%	0%	0%

The Mathematics Observation Tool also sought to observe and measure the primary direction of mathematics communication in the classroom.

- At the elementary level, mathematics communication is primarily from Teacher-to-Student. This is observed in 68 percent of the classrooms. A Balanced Mix of communication directionality is observed in 36 percent of elementary classrooms.
- At the middle school level, mathematics communication is Primarily from Teacher-to-Student. This is observed in 78 percent of the classrooms. A Balanced Mix of communication directionality is observed in 22 percent of middle school classrooms.
- At the high school level, mathematics communication is primarily from Teacher-to-Student. This is observed in 80 percent of the classrooms. In twenty-five percent of classrooms, A Balanced Mix of teacher and student led communication is observed.
- Primarily Teacher-to-Student communication increases as grade level increases.
- Primarily Student-to-Student communication is observed infrequently or not at all across grade levels.

Table 12: Mathematics Communication

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
Primarily Teacher-to-Student	63%	78%	80%
Primarily Student-to-Student	2%	0%	5%
A Balanced Mix of Teacher-to-Student and Student-to-Student Communication	36%	22%	25%

Tables 13 and 14 concern additional staff support in the mathematics classroom and their role in assisting the teacher. Only at the elementary level are additional teachers reported to be observed assisting in the classroom. In middle and high school classrooms any additional staff observed are teaching assistants or their position is not known. Evidence of alternative teaching and team teaching is not observed at all at the middle and high school levels.

- Additional instructional support in the classroom from another teacher or from a teaching assistant is most commonly observed at the elementary level at 45 percent with 17 percent reported to be an additional teacher and 28 percent reported to be a teaching assistant. A variety of co-teaching models are observed with the most common being One Teach, One Assist, followed by Station Teaching, and Parallel Teaching.
- At the middle school level, teaching assistants are observed in 26 percent of the classrooms. A One Teach, One Assist co-teaching model is used 73 percent of the time. Parallel or No Observable Model are both observed at 13 percent.
- At the high school level, teaching assistants are observed in 33 percent of the classrooms. A One Teach, One Assist co-teaching model is used 88 percent of the time. One Teach, One Observe and Station Teaching models are both observed at 6 percent.

Table 13: Additional Teacher or Assistant

	Elementary (n=265)	Middle School (n=69)	High School (n=64)
No	45%	71%	69%
Yes: Teacher	17%	4%	6%
Yes: Teaching Assistant	28%	22%	27%
Yes: Unsure	12%	3%	2%

Table 14: Co-Teaching Model Observed when an Additional Teacher or Assistant is Present

	Elementary		Middle School		High School	
	Teacher (n=45)	Assistant (n=75)	Teacher (n=Less than 5)*	Assistant (n=15)	Teacher (n=Less than 5)*	Assistant (n=17)
Alternative teaching	0%	3%		0%		0%
One teach, one assist	24%	49%		73%		88%
One teach, one observe	2%	9%		0%		6%
Parallel teaching	27%	15%		13%		0%
Station Teaching	29%	20%		0%		6%
Team teaching	36%	4%		0%		0%
No observable model	0%	8%		13%		0%

* Responses are calculated from observations where an observer clearly identified a teacher or an assistant.

A series of questions from the Mathematics Observation Tool were specifically concerned with technology in the classroom. The devices being used include iPads, calculators, laptops, and projectors. In classrooms where technology is observed being used, its use is clearly connected to the lesson's objective and the students' on-task behavior is very high. Also observed is the function of the technological device. In most cases, across grade levels, the devices are being used in two ways: to augment mathematics content; and to substitute for mathematics texts, paper and pencil assignments, or quizzes.

- At the elementary level, technology provided teachers with a record of student performance at 69 percent. The technology is used to augment instruction 66 percent of the time. It is used as a substitute for mathematics resources 30 percent of the time. Three percent of the time it is used to modify instruction and for 1 percent of the time it is used to redefine instruction. Student on-task behavior is observed to be at 100 percent.
- At the middle school level, technology provided teachers with a record of student performance at a lower rate of 35 percent. The technology is used to augment instruction 61 percent of the time. It is used as a substitute for mathematics resources 39 percent of the time. It is not observed to modify or redefine instruction. Student on-task behavior is observed to be at 97 percent.
- At the high school level, technology provided teachers with a record of student performance at 24 percent. The technology is used most often as a substitute for mathematics resources

at 54 percent. It is used to augment instruction 44 percent of the time. Student on-task behavior is observed to be at 90 percent.

Table 15: Technology is Clearly Connected to the Lesson's Objective

	Elementary (n=265/105*)	Middle School (n=69/58*)	High School (n=64/54*)
Yes	94%	100%	94%
No	6%	0%	6%
Unable to observe	2%	1%	2%
N/A	58%	15%	14%

*Response rates for Yes and No are calculated after the removal of N/A and Unable to observe responses

Table 16: Technology Provides Teachers with Record of Student's Performance

	Elementary (n=265/45*)	Middle School (n=69/43*)	High School (n=64/50)
Yes	69%	35%	24%
No	24%	65%	76%
Unable to observe	25%	25%	6%
N/A	58%	13%	16%

*Response rates for Yes and No are calculated after the removal of N/A and Unable to observe responses

Table 17: Students are On-Task while Using Technology

	Elementary (n=265/108*)	Middle School (n=69/58*)	High School (n=64/52)
Yes	100%	97%	90%
No	0%	3%	10%
Unable to observe	1%	1%	2%
N/A	58%	15%	17%

*Response rates for Yes and No are calculated after the removal of N/A and Unable to observe responses

Table 18: Utilization of Technology

	Elementary (n=265/109*)	Middle School (n=69/59*)	High School (n=64/52*)
Substitute	30%	39%	54%
Augment	66%	61%	44%
Modify	3%	0%	0%
Redefine	1%	0%	2%
Unable to observe	0%	0%	2%
N/A	59%	15%	17%

*Response rates for Yes and No are calculated after the removal of N/A and Unable to observe responses

Summary of Mathematics Observation Tool

The Mathematics Observation Tool findings demonstrate that very intentional mathematics instruction is taking place in APS classrooms. Lesson objectives are aligned to curriculum goals. New learning is connected to previous learning building a stronger foundation of mathematical understanding which lay the groundwork for future learning and promotes higher-level critical

thinking. There is very purposeful use of mathematical language and frequent opportunities for students to demonstrate and communicate their thinking in order to deepen students' understanding of mathematics and supports the development of a community of mathematics learners.

While there is evidence of the use of technology in the classroom, the potential to provide even greater benefit to individual student success exists. There are opportunities to more effectively utilize technology as a student assessment tool and as a tool to differentiate instruction

Mathematics Surveys

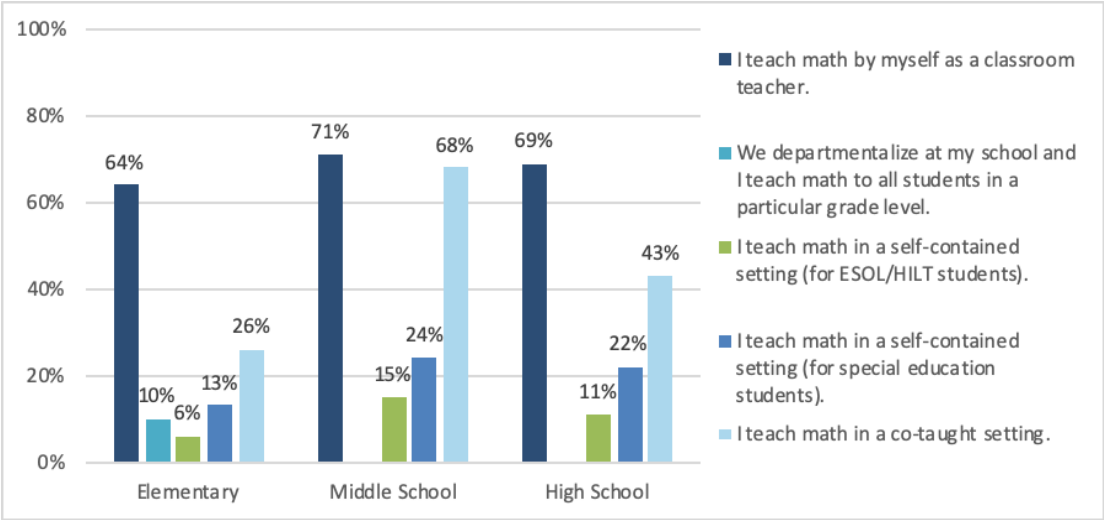
Mathematics Surveys were administered to school administrators, classroom teachers, and students in grades 5-12 in Spring 2018. The survey questions obtain information about several categories of mathematics instruction, including teacher content knowledge, teacher ability to differentiate instruction through remediation and/or extension, and provision of appropriate challenge and support for students. Responses also provide direct evidence and insight into professional collaboration, use of data for planning mathematics instruction, and use of resources in order to determine program areas of strength and weakness.

The student survey included pre-populated demographic data. This means that information about students' demographic characteristics was automatically entered into the survey when the student entered their access code. This includes such variables as race/ethnicity, gender, special education and ESOL/HILT participation, and course enrollment.

Collaborative Planning

The teachers responding to this survey are providing mathematics instruction to students of all age and ability levels, including English Learners (EL) taught in EL classrooms and Students with Disabilities (SWD) served in special education classrooms. The following graph shows the type of instructor and their role in teaching mathematics.

Figure 5: Role in Teaching Mathematics



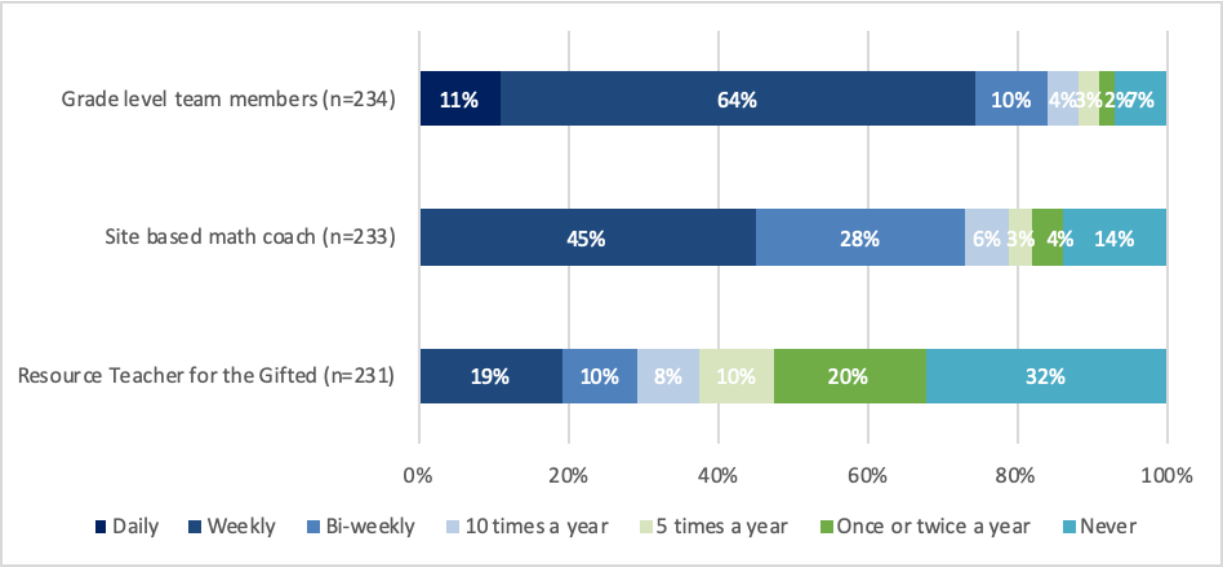
- At the Elementary level, there are more EL teacher respondents.
- At the Elementary and Middle School levels, mathematics coaches represented four to five percent of the responses.
- Student needs are being met in a regular classroom setting, a co-taught setting, or self-contained classrooms.

Several survey questions assess the extent to which mathematics instructional staff collaborate and plan with other members of the mathematics team. Overall, grade-level and content-area Collaborative Learning Teams (CLTs) report meeting at least weekly. Across grade levels, it is uncommon for teachers to collaborate with the resource teacher for the gifted (RTG). At the Middle and High School levels, collaboration with Special Education teachers is more frequent than with the RTG or EL teacher. The following graphs provide more detail into that practice.

Elementary School Staff collaborative planning practices:

- In Elementary Schools, weekly collaboration with grade-level team members is reported to occur at 64 percent. Eleven percent of teachers state they meet with grade-level team members meet daily. Seven percent state they never meet with grade-level team members.
- Collaboration with school-based mathematics coaches is reported to occur weekly by 45 percent of teachers, followed by bi-weekly collaboration at 28 percent. Fourteen percent of responses indicate that they do not collaborate with the school-based mathematics coaches.
- Twenty percent of the elementary school teachers report that they collaborate with the RTG once or twice a year. At the Elementary School level, 32 percent report never collaborating with the RTG.

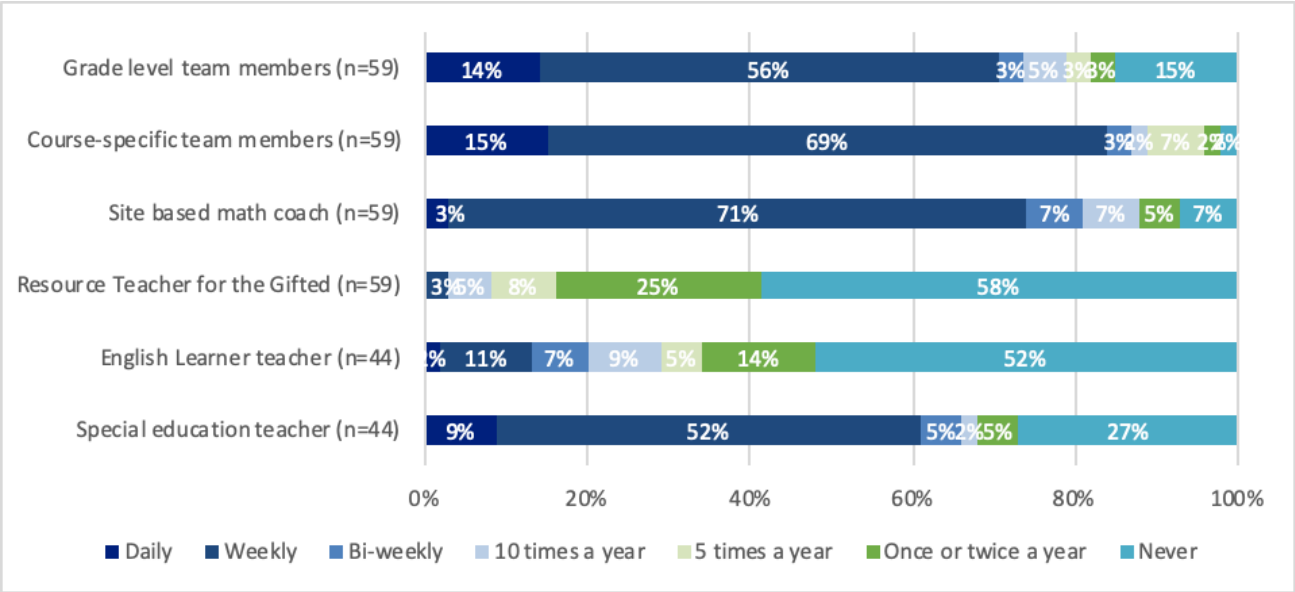
Figure 6: Elementary School Collaborative Planning



Middle School Staff collaborative planning practices:

- In Middle School, weekly collaboration with grade-level team members is reported to be at 56 percent. Daily collaboration with grade-level team members occur with 14 percent of teachers. Fifteen percent report they never collaborate with grade-level team members.
- Collaboration with school-based mathematics coaches is reported to occur weekly by 71 percent of teachers.
- At the Middle School level, 69 percent of teachers report weekly collaboration with course-specific team members. Daily collaboration is reported at 15 percent.
- Twenty-five percent of Middle School teachers report that they collaborate with the RTG once or twice a year and 58 percent report never collaborating with the RTG.
- Middle School mathematics teachers report that collaboration with EL teachers is uncommon with 52 percent of responses indicating that they never collaborate with EL teachers. For those who do collaborate, 14 percent of responses show that the frequency is at once or twice a year. Eleven percent of responses show that the frequency was weekly.
- At the Middle School level, collaboration with EL teachers decreases as grade level increases.
- At the Middle School level, collaboration with Special Education teachers is most commonly reported to occur on a weekly basis at 52 percent, followed by daily collaboration at 9 percent. Twenty-seven percent of those surveyed report they do not collaborate with special education teachers.

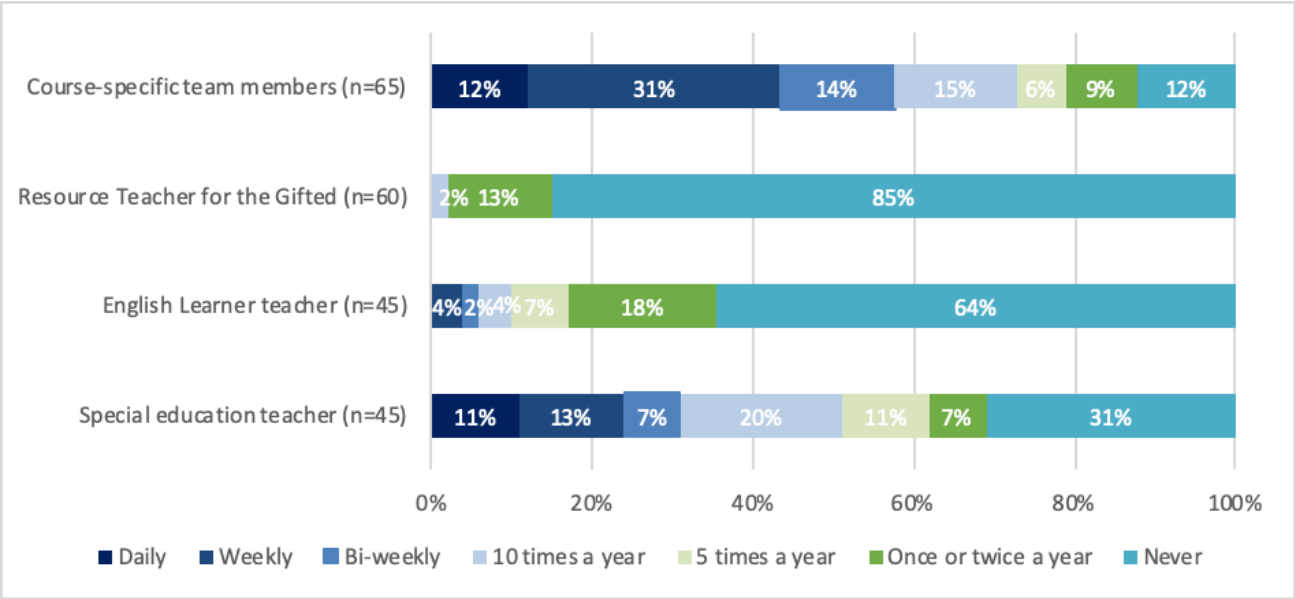
Figure 7: Middle School Collaborative Planning



High School Staff collaborative planning practices:

- At the High School level, weekly collaboration with course-specific team members is reported at 31 percent. Once every other month is the next most common occurrence of collaboration at 15 percent. Twelve percent of the responses indicate that they never collaborate with course-specific team members.
- Thirteen percent of High School teachers report that they collaborate with the RTG once or twice a year. At the High School level, 85 percent of teachers report that they never collaborate with the RTG.
- High School mathematics teachers also report that collaboration with EL teachers is uncommon with 64 percent of responses indicating that they never collaborate with EL teachers. For those who do collaborate, 18 percent of responses showed that the frequency was at once or twice a year.
- At the High School level, collaboration with special education teachers is most commonly reported to occur at 20 percent. Thirty-one percent of those surveyed report they do not collaborate with special education teachers.

Figure 8: High School Collaborative Planning



Using Data for Planning Mathematics Instruction

Teachers were asked to report on assessment types and how they are used. The following graphs show the types of assessments that teachers evaluate to plan mathematics instruction and the frequency with which they refer to those assessments for their planning. The actions teachers take based on the review of that data is also shown. (Note: The Data Used graph reflects which assessments teachers rely on the most. The Actions Taken graph reflects what adjustments teachers make when they *do* refer to that particular type of data.)

All teachers, at all levels, indicate that student work and informal formative assessments (observation, student contributions to class) are the most significant types of data referred to and acted on when planning instruction to target the needs of diverse learners. Though teachers report using the formative assessments from PowerSchool, its use is infrequent. A significant number of teachers state they never refer to formative assessments from PowerSchool. Of those who state they refer to those assessments, almost all use that data to make adjustments to instruction. Other formal formative assessments, such as exit tickets and warm-ups, are another source of data teachers use regularly to adjust instruction to target diverse learners. Overall, teachers are using student data frequently to modify instruction to target the needs of diverse students. Across grade levels, teachers are the most likely to adjust instruction based on student work. They are least likely to arrange an extension based on student data.

- At the Elementary School level, teachers report they rely most heavily on informal formative assessments, at 85 percent, and student work, at 80 percent, to plan instruction. Twenty-seven percent of respondents state they never refer to PowerSchool. However, they do use other formal formative assessments daily or weekly.

- At the Middle School level, teachers report they rely most heavily on informal assessments, at 83 percent, and student work, at 71 percent, to plan instruction. Thirty-nine percent of respondents state they never refer to PowerSchool. Middle school teachers use other formal formative assessments on a daily and weekly basis, at 46 and 49 percent, respectively.
- At the High School level, teachers report they rely most heavily on informal assessments, at 81 percent, and student work, at 73 percent, to plan instruction. Forty-six percent of respondents state they never refer to PowerSchool. High school teachers use other formal formative assessments on a daily and weekly basis, at 50 and 20 percent.

Figure 9: Elementary School – Data Used to Plan Mathematics Instruction to Target Needs of Diverse Learners

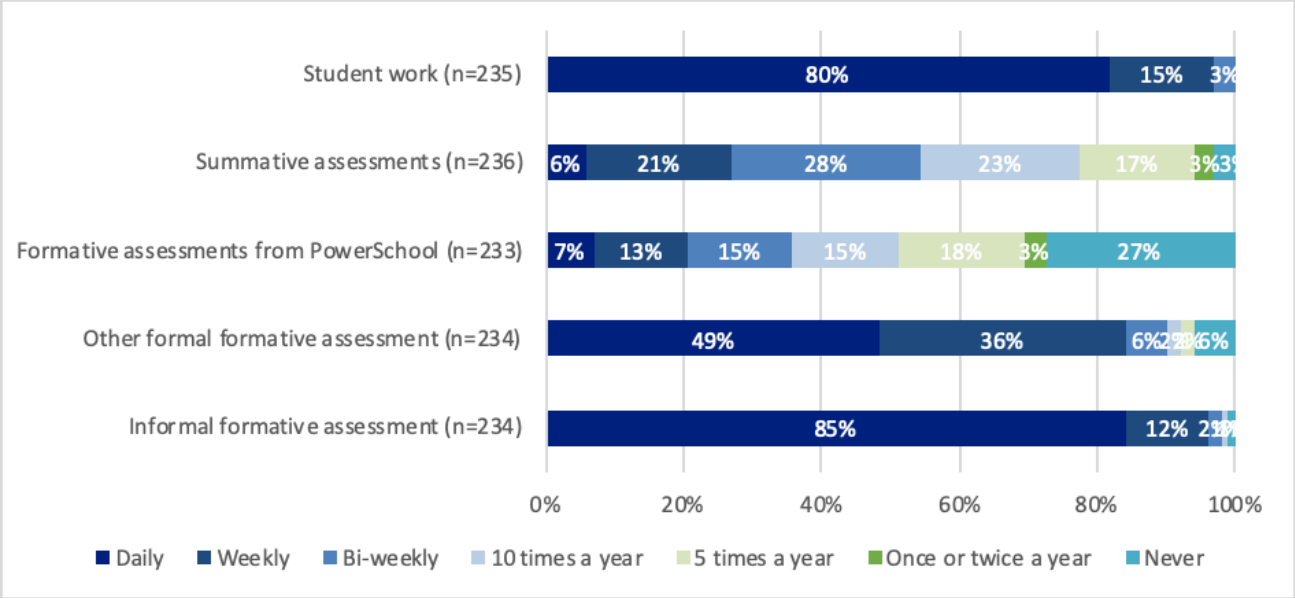


Figure 10: Elementary School – Actions Taken Based on Review of Student Data

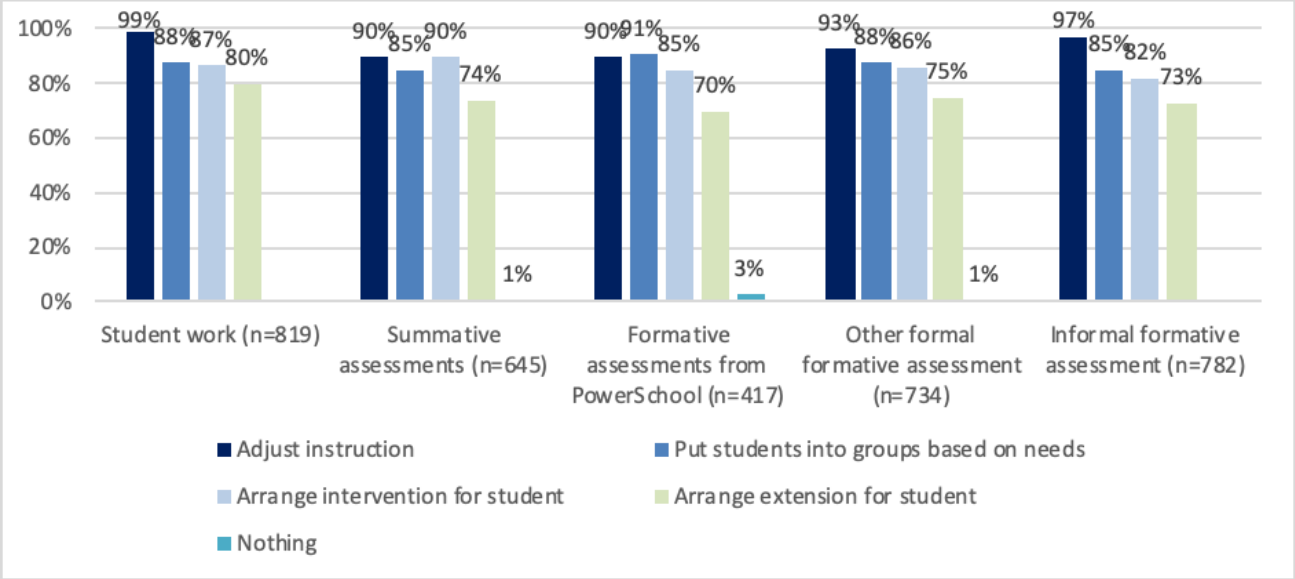


Figure 11: Middle School – Data Used to Plan Mathematics Instruction to Target Needs of Diverse Learners

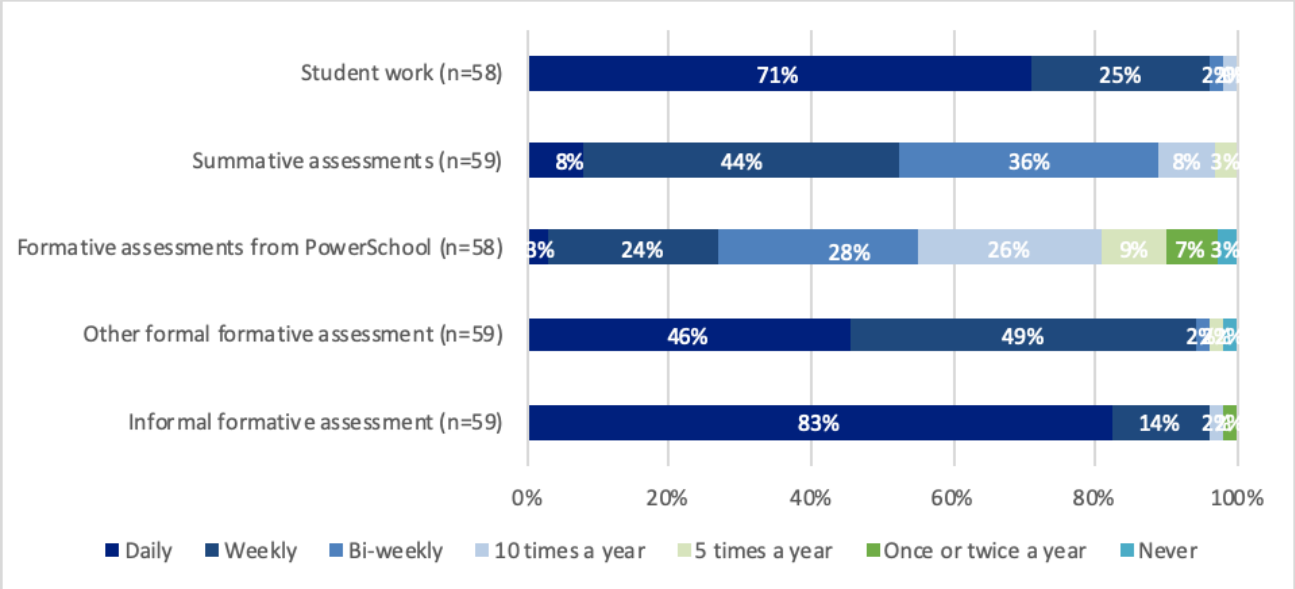


Figure 12: Middle School – Actions Taken Based on Review of Student Data

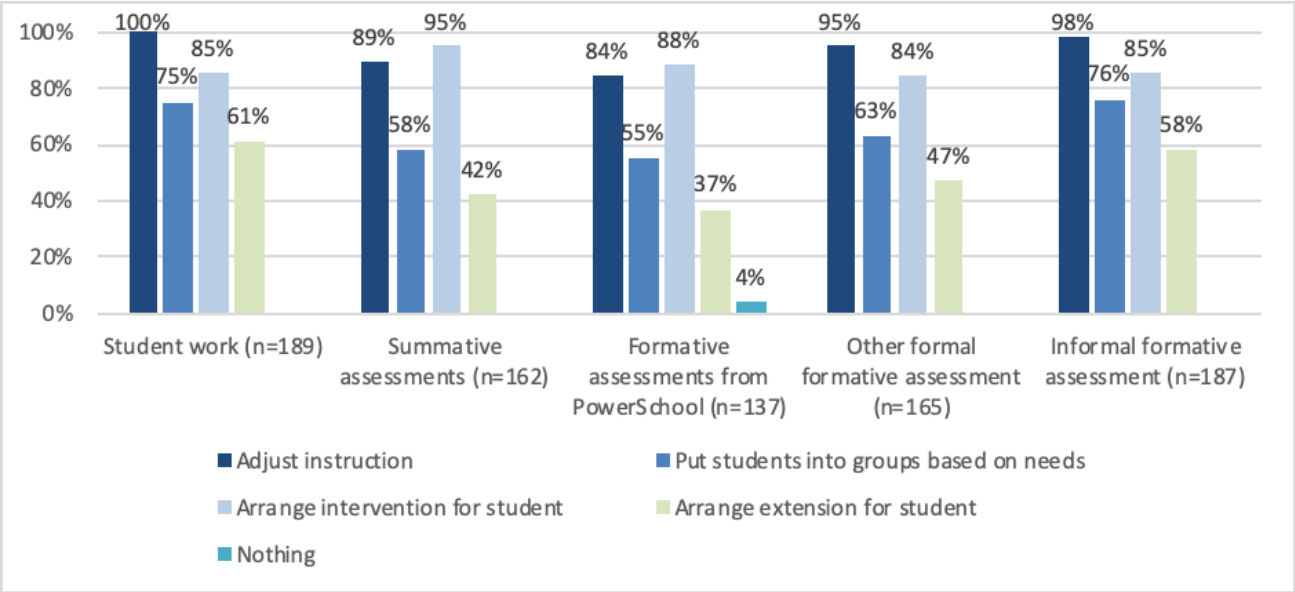


Figure 13: High School – Data Used to Plan Mathematics Instruction to Target Needs of Diverse Learners

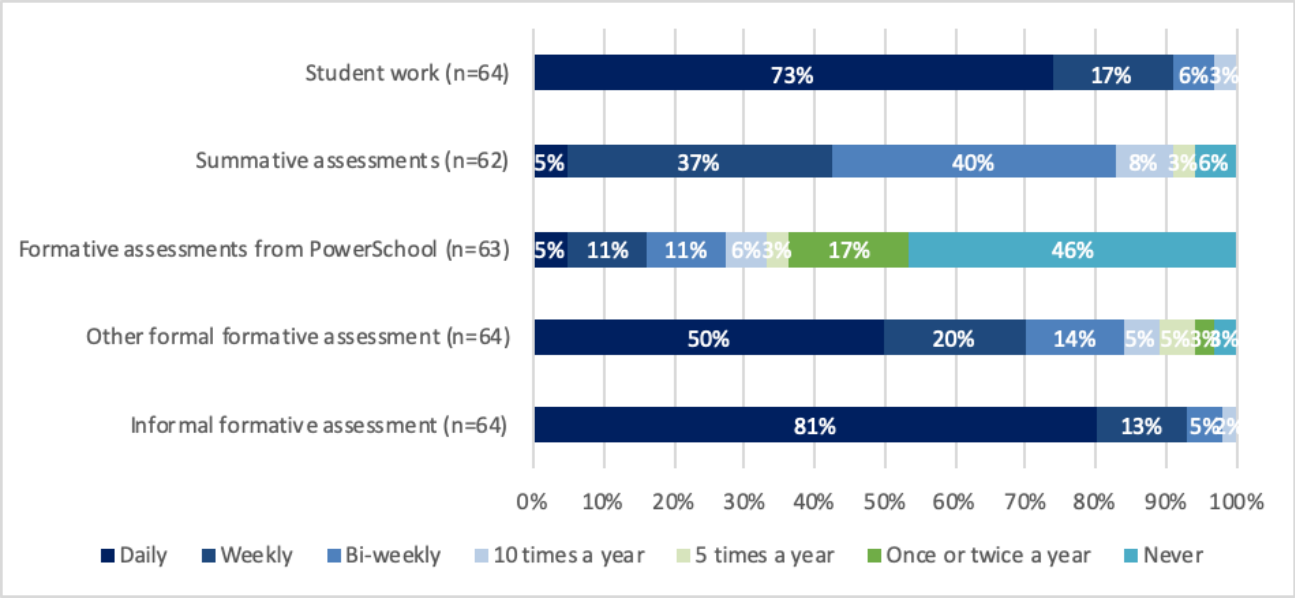
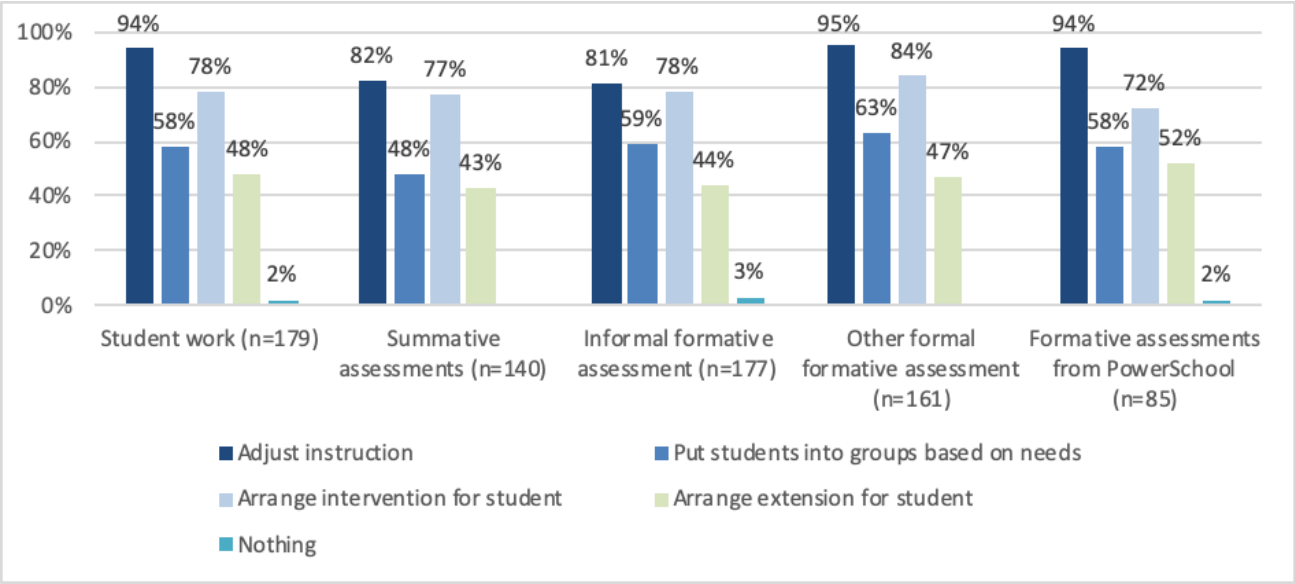


Figure 14: High School – Actions Taken Based on Review of Student Data

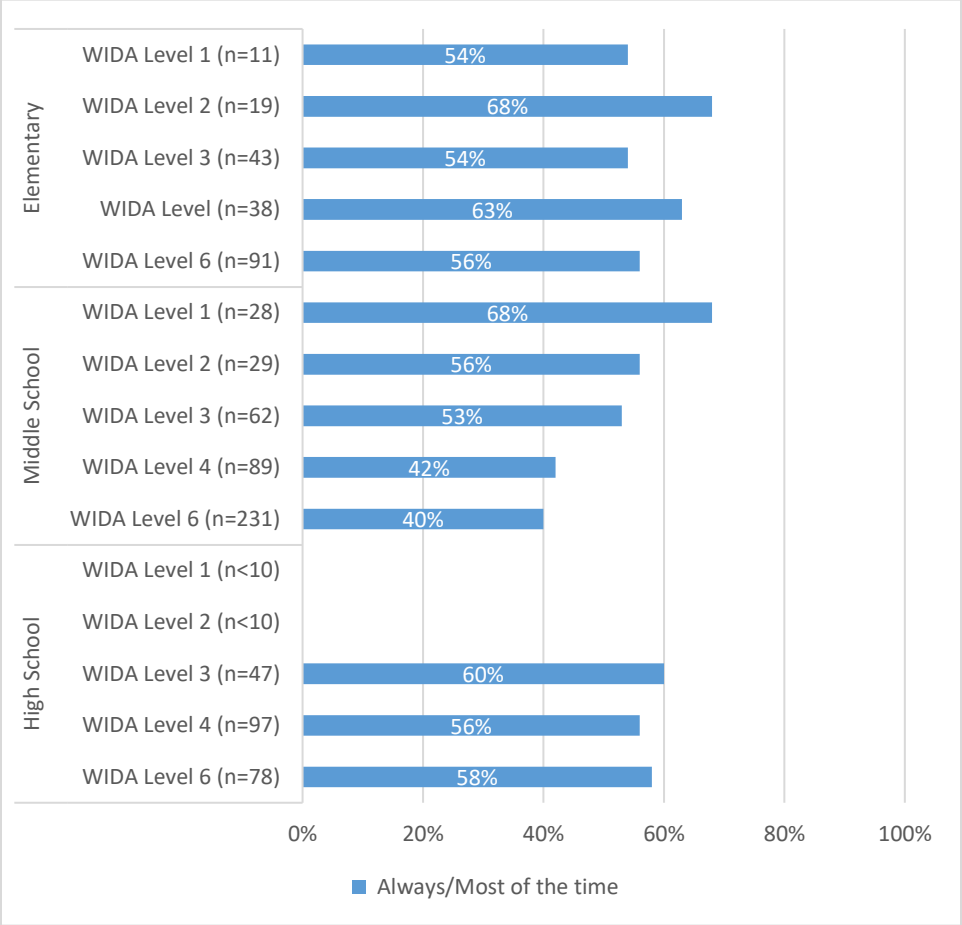


Student Feedback

The Mathematics Survey asked for student feedback on mathematics instruction. The information given by the students is displayed on the graphs below. Though a majority of students who are English Learners indicate that the teacher helps them understand the English if it is difficult for them Always or Most of the Time, those responses vary by grade level and WIDA language proficiency level.

- Elementary School responses range from 54 to 68 percent, fluctuating between WIDA language proficiency levels.
- Middle School students at the lowest WIDA language proficiency level indicate they receive help 68 percent of the time and that the help decreases as their WIDA language proficiency increases.
- High School responses show similar scores across WIDA language proficiency levels ranging from 56 to 60 percent.

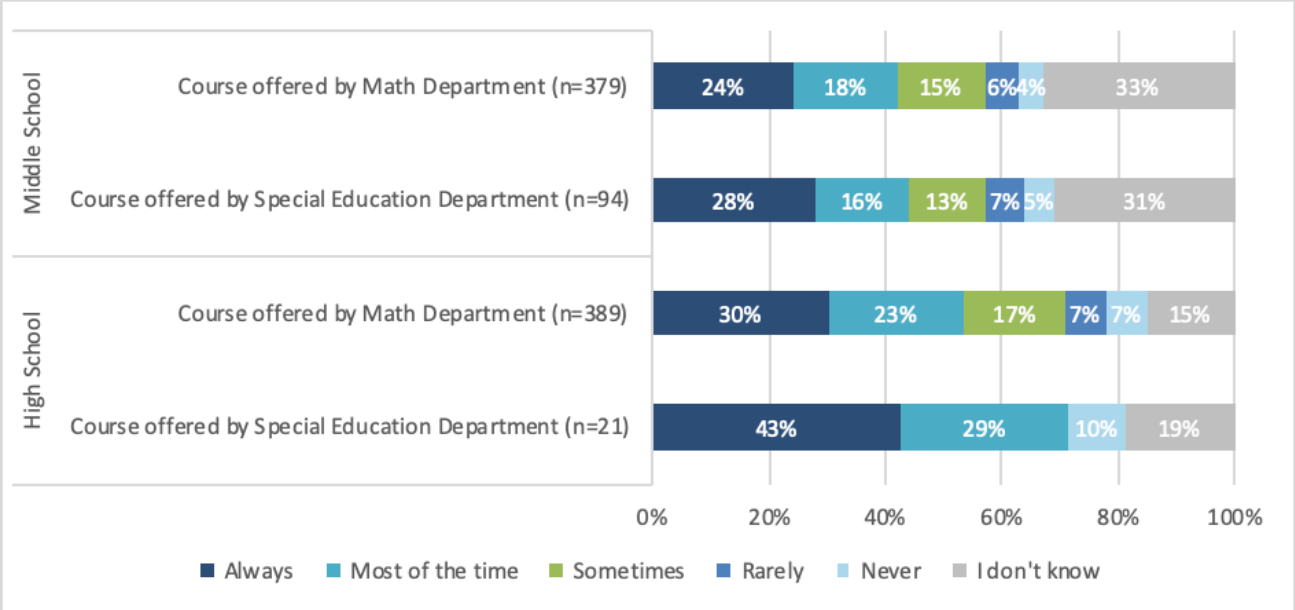
Figure 15: Does Your Teacher Help You Understand the Mathematics Lesson if the English is Too Difficult for You?



Responses regarding students with IEPs or 504 Plans indicate that:

- At the middle school level, students feel that those with an IEP or 504 Plan are equally likely to receive help understanding the lesson if they are in a special education classroom or in a regular education classroom, but only at 42 or 44 percent respectively.
- At the high school level, however, students feel that those with an IEP or 504 Plan are much more likely to receive help in a special education classroom, at 72 percent, as compared to the regular education classroom, at 53 percent.

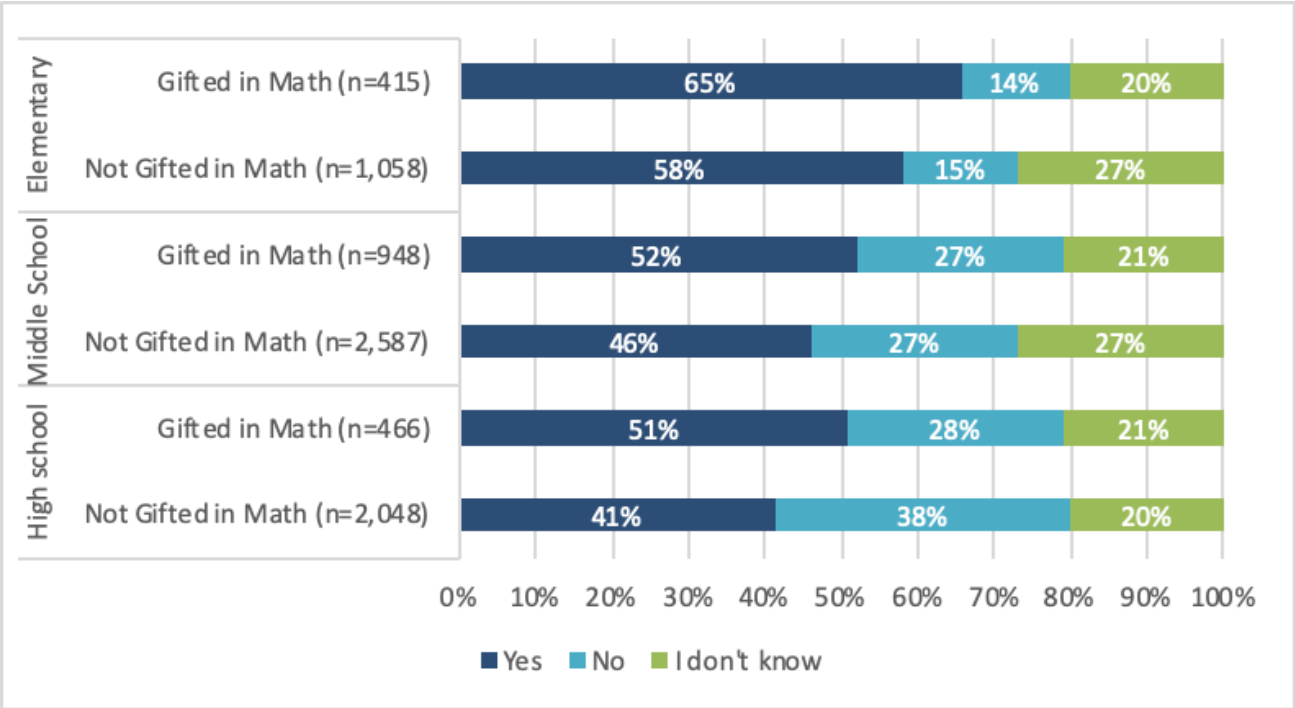
Figure 16: Does Your Mathematics Teacher Help Students Who Have an IEP or 504 Plan to Understand the Lesson?



The following three graphs compare the responses of students identified as gifted in mathematics and those not identified as gifted in mathematics as it relates to being encouraged to explore areas of interest in the mathematics classroom, students being challenged to think at a higher level in the mathematics classroom, and students having the ability to make choices about lessons or activities in the mathematics classroom.

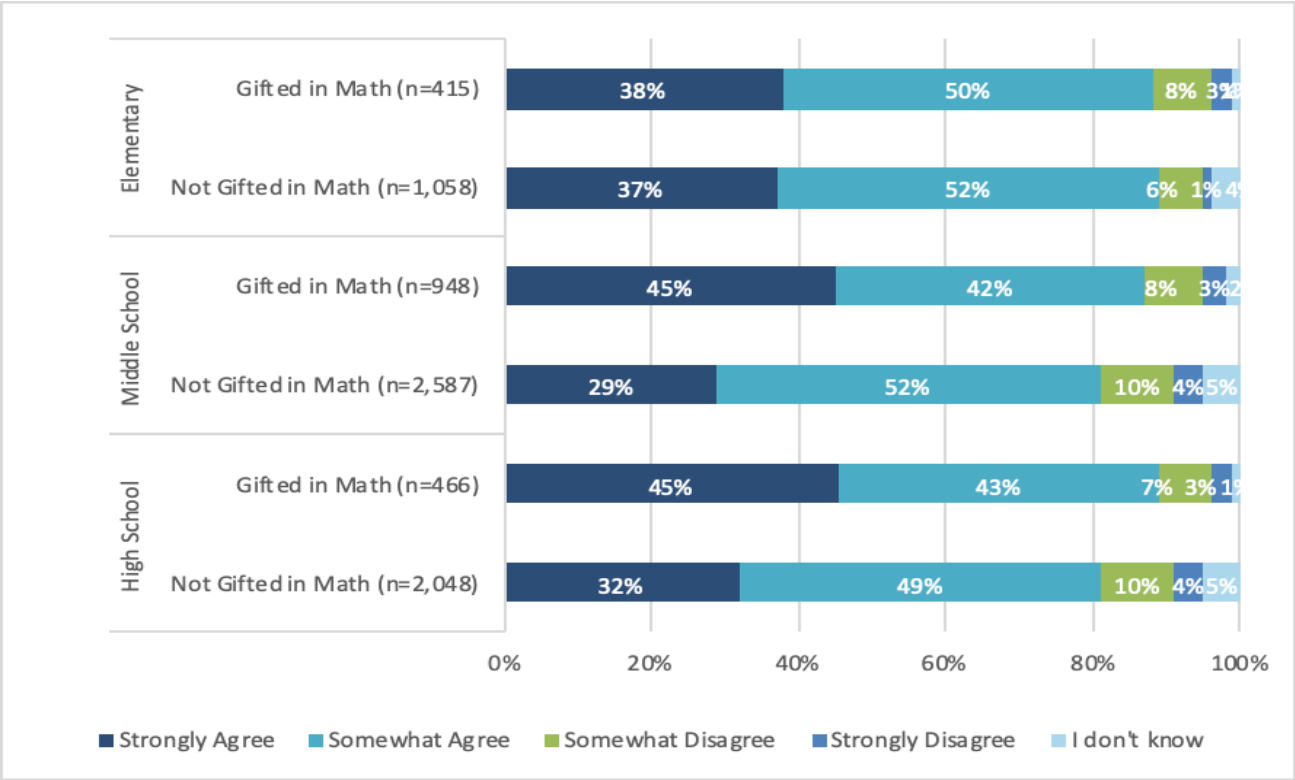
- Encouragement to explore mathematics topics of interest happens more frequently with gifted mathematics students, with a high of 65 percent in elementary school and decreasing at the middle and high school levels by more than 10 percent.
- However, students not identified as gifted in mathematics at each grade level also respond that teachers encourage them to explore mathematics topics as well, at 58, 46, and 41 percent at the elementary, middle, and high school levels respectively.

Figure 17: Does Your Mathematics Teacher Encourage You to Explore Mathematics Topics that You are Curious or Interested In?



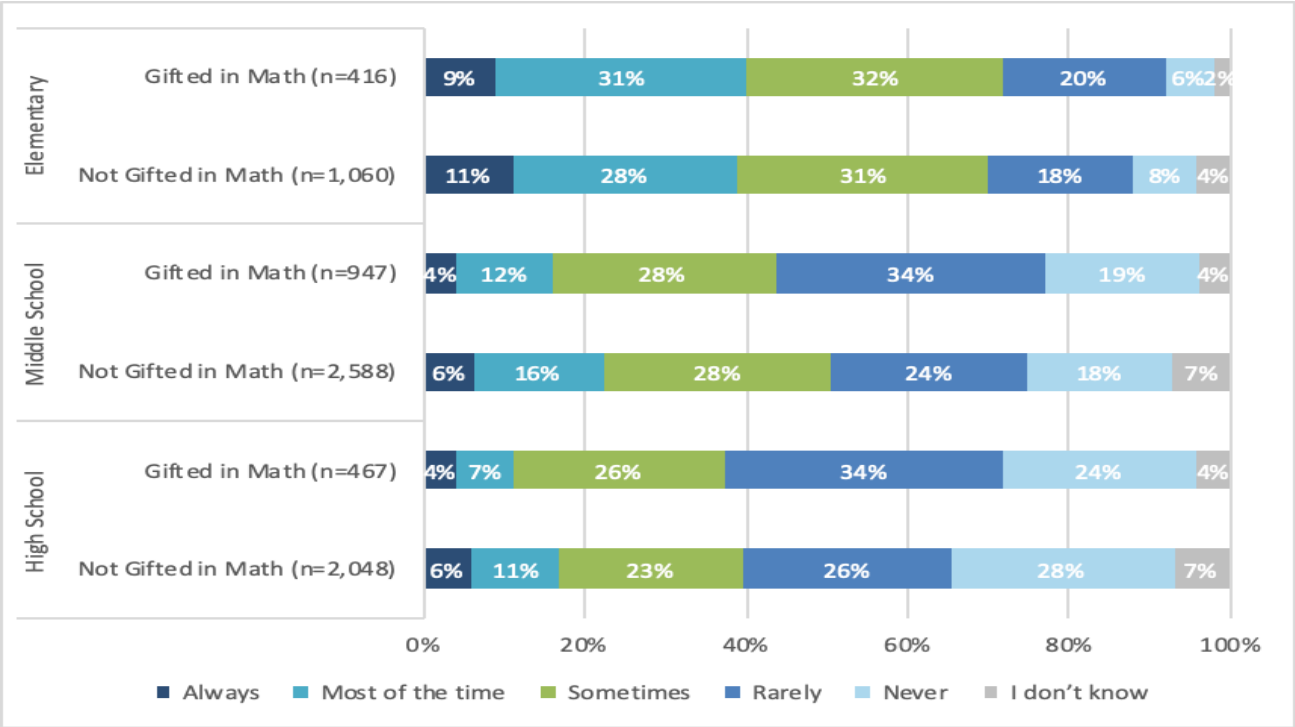
In Figure 18, when combining the Strongly Agree and Somewhat Agree responses, gifted mathematics students and mathematics students not identified as gifted both indicate similar levels of agreement that they are being challenged in their mathematics classrooms. Gifted students indicate a higher level of Strong Agreement that they are being challenged to solve problems critically and creatively, especially at the middle and high school levels.

Figure 18: My Mathematics Classes Challenge Me to Think at a Higher Level or Solve Problems Critically and Creatively



Across grade levels, students respond that they are able to select activities and lessons in their mathematics classrooms at least Some of the Time. The ability to make those choices decreases as the grade level increases, but even at the high school level, 37 percent of gifted mathematics students and 40 percent of mathematics students not identified as gifted respond that they have some ability to make choices about the activities and lessons they participate in.

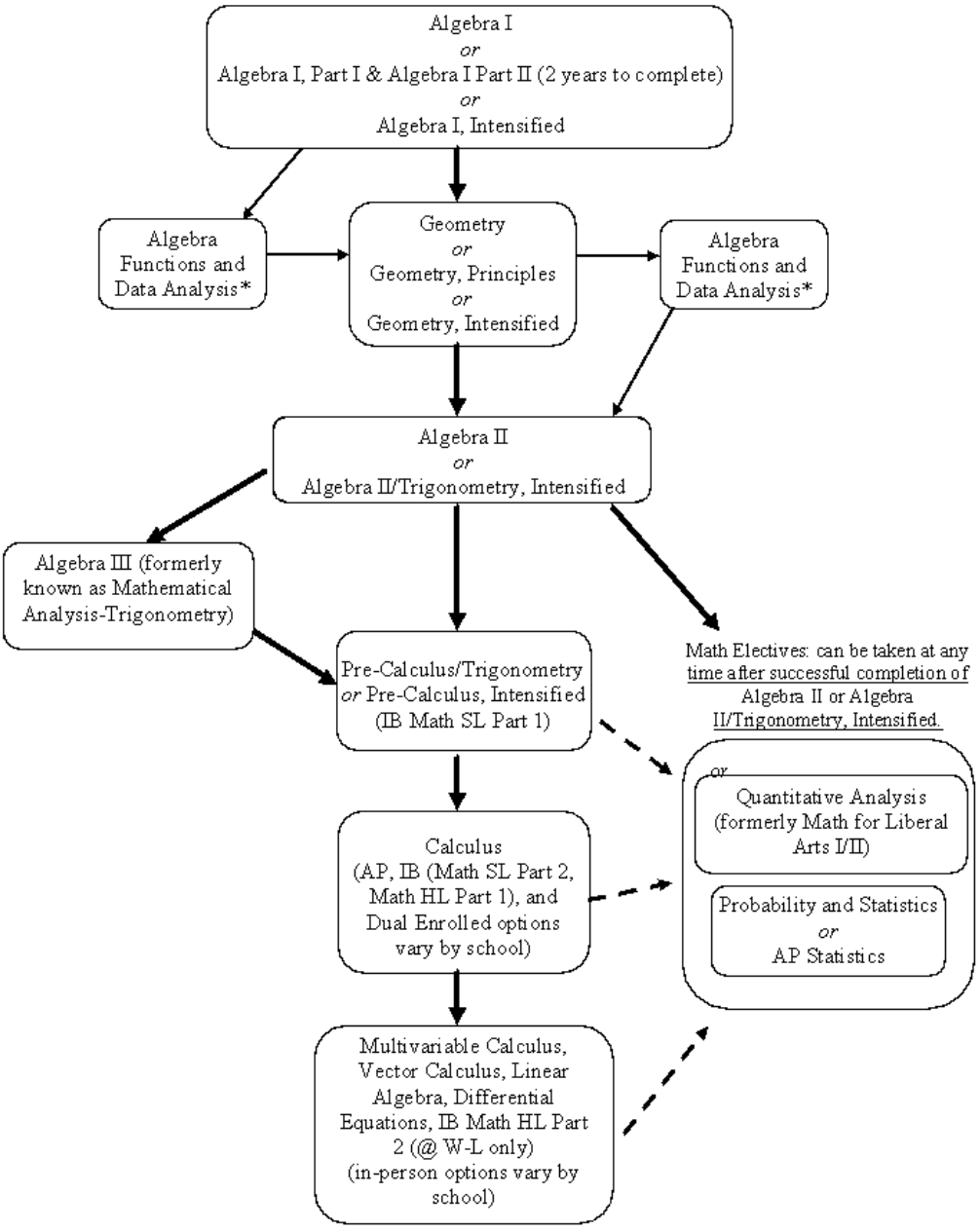
Figure 19: I Can Choose Some of the Lessons or Activities I Participate in During Mathematics Class



STUDENT ACCESS

Arlington Public Schools' Math Course Pathways from Algebra I and on (2019-2020)

Students will enter these pathways when enrolled in any Algebra I course (which will occur at different grade levels). There are multiple pathways and courses that students may take depending upon their readiness. Please see specific course descriptions for prerequisite requirements



For specific IB and Dual Enrolled courses not mentioned here, please see the index of courses offered at individual high schools.
Students needing additional support may be concurrently enrolled in Algebra I, Geometry, or Algebra II and a Strategies course.
*AFDA may be taken after Algebra I and before Geometry OR after Geometry and before Algebra II in high school only.

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Hanover Research Council Longitudinal Study

The Hanover Research Council (HRC), an information research and analytics firm, was contracted by APS to prepare a longitudinal study evaluating the various mathematics course pathways APS students take from middle school through high school. The report includes two cohorts of students - Cohort 2017 (students who graduated from APS at the end of the 2016-17 academic year), and Cohort 2018 (students who graduated from APS at the end of the 2017-18 academic year). These students were continuously enrolled in APS. The study is intended to assess the following:

- Student access to advanced level mathematics courses, including college-level courses in high school, and
- The various trajectories students take, as a whole group and disaggregated by demographic group, to help determine areas of strength and weakness in the APS Mathematics Program.

In addition to using the Key Findings reported by the HRC, the Mathematics Office is able to look at the trends and trajectories of mathematics course pathways which provide helpful information in the identification of specific times during student movement through their mathematics course sequence where support and intervention is needed. The pathways can be broken down by single demographic group (e.g., Limited English Proficiency) or by combining demographic groups (e.g., Hispanic, LEP, Student with a Disability). This information results in intentional responses regarding the allocation of staff, professional development, and county resources. It also helps to inform curricular responses such as program design and instructional strategies in the classroom.

Here are the Key Findings reported by the Hanover Research Council:

Student involvement in college-level mathematics courses in Grade 11 and 12 can largely be predicted by course enrollment in earlier grade levels. College-level courses include AP Calculus BC, AP Statistics, Multivariable Calculus, etc.

> The vast majority of students (92.1 percent, 425 out of 457 students) who take an advanced course in Grade 6 eventually go on to take at least one high-level course, while only approximately 44.3 percent of students who take Mathematics 6 in Grade 6 eventually take at least one AP/IB mathematics course by the end of high school.
>
> Similar patterns are observed in other grade levels as well. Specifically, a higher proportion of students who take an advanced course from Grade 7 to 10 eventually take at least one college-level course compared to their peers who take regular courses or below in the same grade.
>
> Only a few students who take Special Education courses, EL courses, or extra support courses together with a regular course from Grades 6 to 9 eventually take any college-level courses by the end of high school.

There is not much upward movement from one mathematics trajectory to another after the Grade 6 to Grade 7 transition. While many students move up one level in Grade 7 (e.g., skipping from Mathematics 6 to Mathematics 8 for 7th graders or from Mathematics 7 for 7th graders to Algebra l Intensified), very few make similar jumps in later grades.

The Grade 7 to Grade 8 transition is an important dividing point for access to college-level coursework. Students in Mathematics 7 in Grade 7 have different probabilities of taking at least one college-level course by the end of high school based on their Grade 8 mathematics course choice.

Approximately one third of students who take Algebra l, Intensified in Grade 8 eventually take at least one college-level course by the end of high school; however, only around 11.4 percent of students who take Mathematics 8 in Grade 8 ultimately take high-level courses in Grades 11 and 12.

Many of the Mathematics 8 students who do make it to advanced mathematics courses by the end of high school do so by taking both Algebra l and/or Geometry in Grade 9. Out of 37 continuously enrolled students who were enrolled in Mathematics 8 in Grade 8 and then proceeded to college-level courses, 35 took Algebra l or Geometry in Grade 9.

There is more variation in students' Grade 12 mathematics course choices than in earlier grades. Approximately 87 percent of students who are consistently enrolled in APS from Grades 6 to 12 take a mathematics course in Grade 12.

For students who take college-level courses as terminal courses in Grade 12, approximately 29.2 percent took AP Calculus AB, 26.6 percent took AP Statistics, 11.6 percent took IB Mathematics, and 11.4 percent enrolled in AP Calculus BC.

For students who take regular classes as terminal classes in Grade 12, the most popular course is Probability & Statistics, followed by Precalculus/Trigonometry and Algebra II.

There are notable differences in course trajectory pathways between members of different demographic subgroups. Specifically, African American and Hispanic students, male students, and students who have ever been classified as SPED, LEP, or economically disadvantaged are less likely to take course pathways that include advanced courses or any college-level mathematics courses by the end of high school, compared to White and Asian students, female students, and students who have never been classified as SPED, LEP, or economically disadvantaged.

The two graphics below, Figures 20 and 21, display APS student pathways as they move through middle school and high school mathematics courses for both the 2016-17 and 2017-18 Cohorts.

- Hanover identified four trajectories that APS students tend to take while moving through the mathematics course sequence. These are meant to represent common pathways students take, but as evidenced by the graphics below, there are myriad options for students to progress through mathematics courses.
    - Trajectory I: Students take the most advanced courses available for their grade level starting from Mathematics 7 for 6th Graders or Mathematics 8 for 7th Graders.
    - Trajectory II: Students take advanced courses but normally with a one-year lag as compared to Trajectory I students.
    - Trajectory III: Students tend to take mostly regular classes during their middle and high school career.
    - Trajectory IV: This trajectory captures all other students, including those who take special education or remedial courses or are not taking any mathematics courses at all.

Figure 20: Hanover Mathematics Course Sequence 2016-17 Cohort (All)

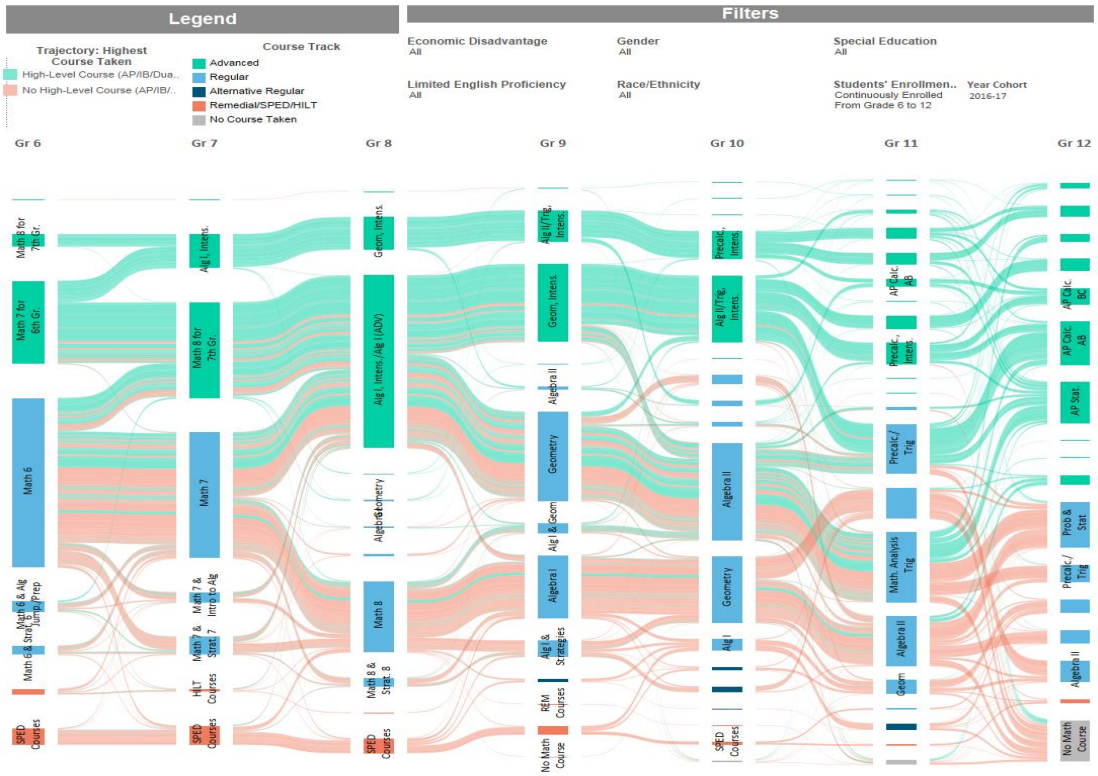


Figure 21: Hanover Mathematics Course Sequence 2017-18 Cohort (All)

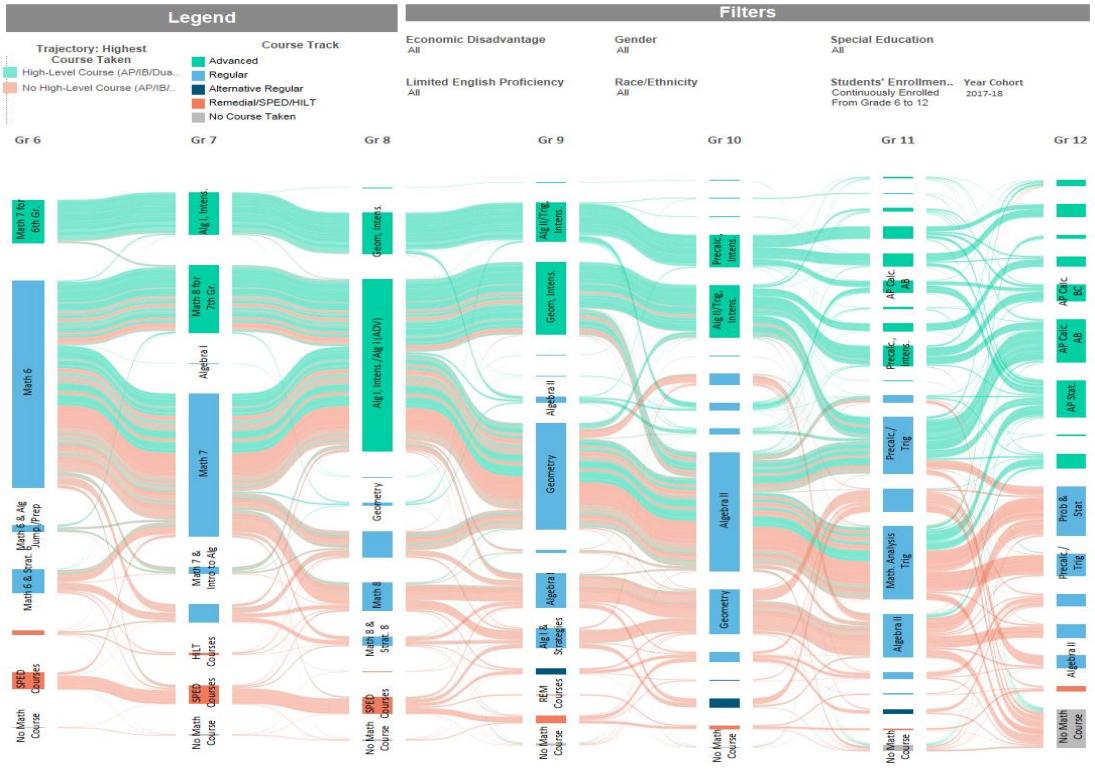


Figure 22: All Students Grades 6 - 9 [2-Level Dashboard 2016-17]

- The boxed section of the graph indicates that students are not "tracked" into a course trajectory by enrollment in grade-level mathematics in Grade 6. About 1/5 of the students who begin in grade-level mathematics in Grade 6 move to an intensified/accelerated pathway by Grade 9. Conversely, about 1/5 of students beginning on an accelerated pathway move to a non-intensified course by Grade 9.

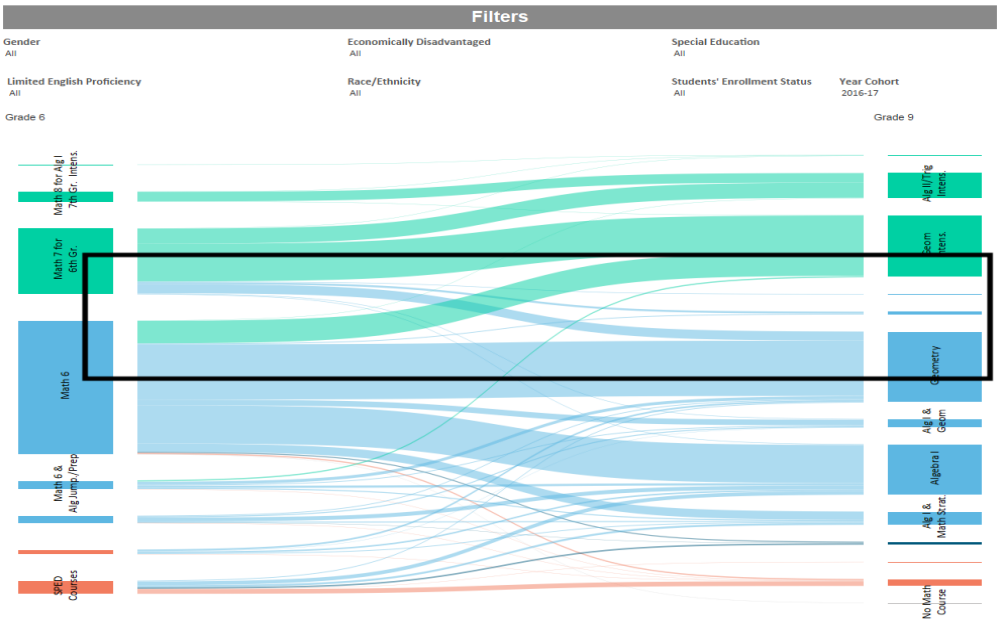


Figure 23: All Students Grades 9 - 12 {2-Level Dashboard 2016-17]

- Students who begin high school on a non-accelerated mathematics trajectory are still able to take a college-level course by Grade 12 as indicated by the light green pathways emerging from the blue grade-level course boxes.
- Some students who start high school in an intensified course as a freshman do not take a mathematics class their senior year. Each intensified freshman course has a gray path coming out of it.

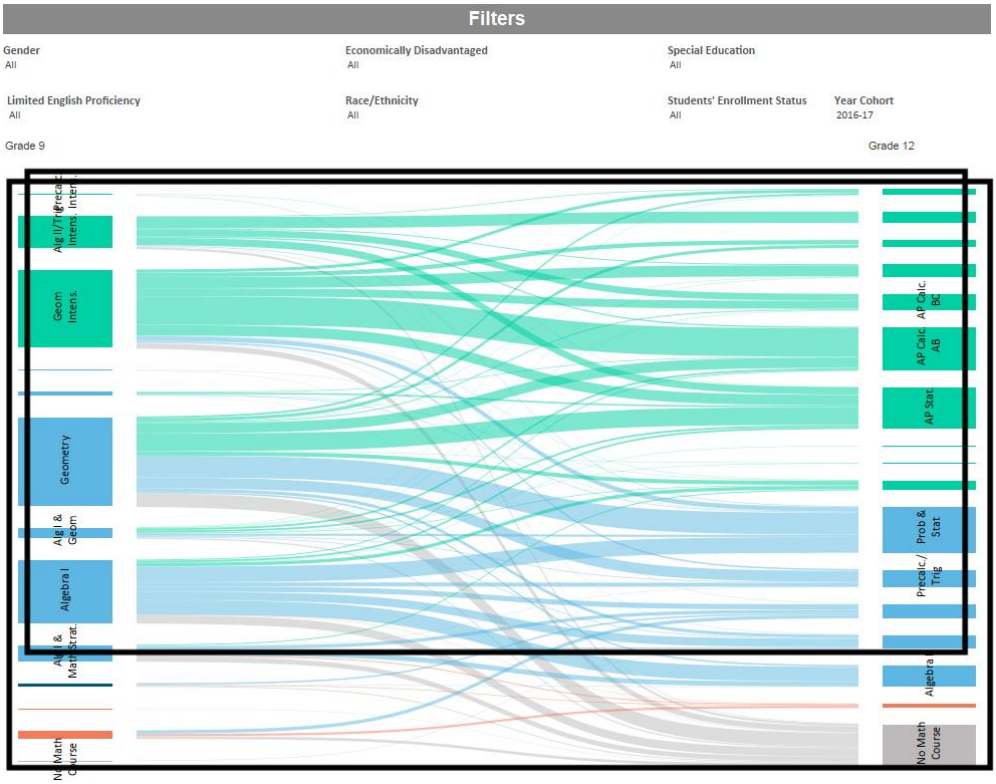
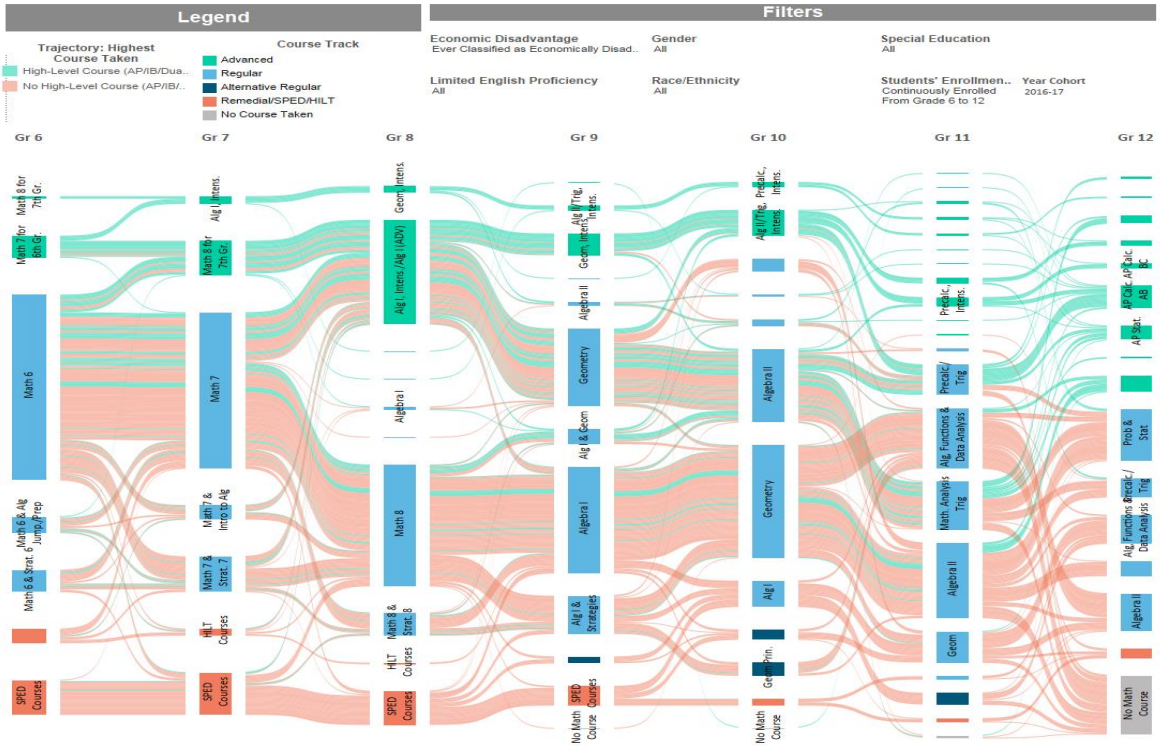


Figure 24 below displays APS student pathways that English Learners (EL) have taken.

- In Grade 6, 5 percent of EL students are in advanced mathematics classes. By the end of Grade 12, more than 30 percent of EL students have taken at least one advanced or college-level course.
- Over 80 percent of EL students finish high school having completed four years of mathematics coursework. Just over 17 percent do not take a fourth year of mathematics at the high school level.

Figure 24: Mathematics Course Sequence Pathways of English Learners - 2016-17



Figures 25 through 28 provide more detailed information about the progress and patterns of students who are English Learners.

Figure 25: English Learners Grades 6 - 9 [2-Level Dashboard 2016-17]

- Significantly fewer English Learners were enrolled in an intensified course by Grade 9. There are EL students, however, who move from Jump Start to an intensified course. This is not seen with Non-EL students.
- EL students beginning middle school in Mathematics 6 are less likely than Non-EL students to be enrolled in intensified courses by Grade 9, However, some EL students who are enrolled in JumpStart, HILT and Special Education, take intensified courses by Grade 9.

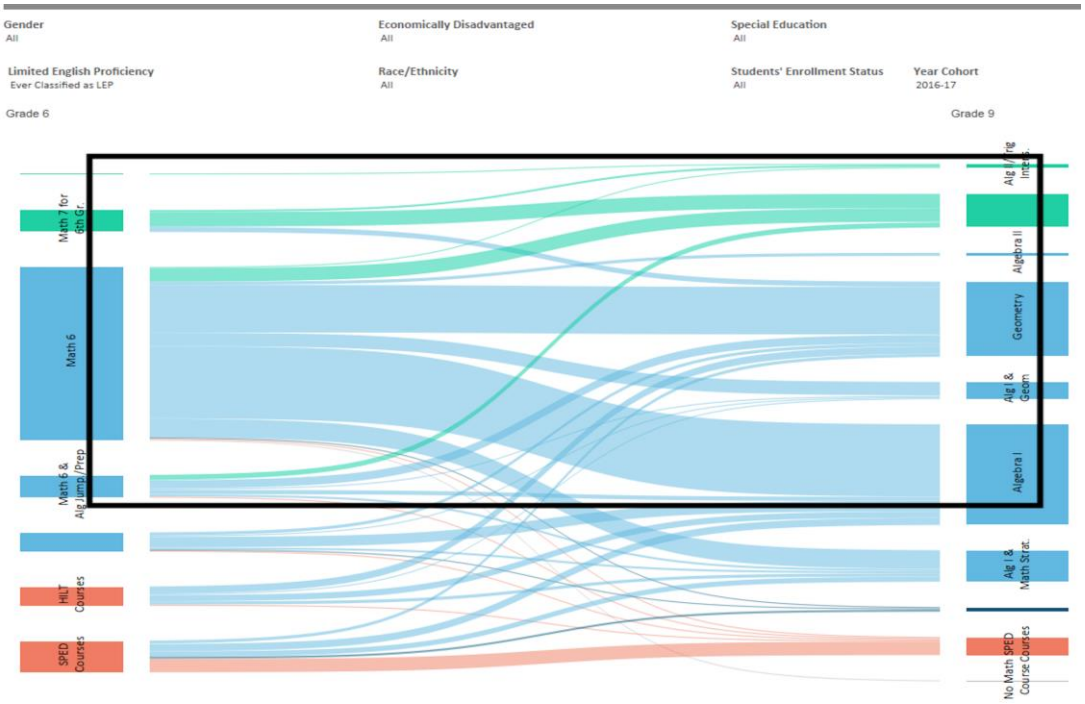


Figure 26: Non-EL Students Grades 6 - 9 [2-Level Dashboard 2016-17]

- About 1/4 of the Non-EL students in Mathematics 6 take Intensified Geometry in 9th grade.
- Some students in Mathematics 7 for 6th graders (an intensified course) do not take an intensified mathematics course in 9th grade.
- No Non-EL students in Mathematics 6 who take the enrichment summer program ended up taking an intensified mathematics course in 9th grade.

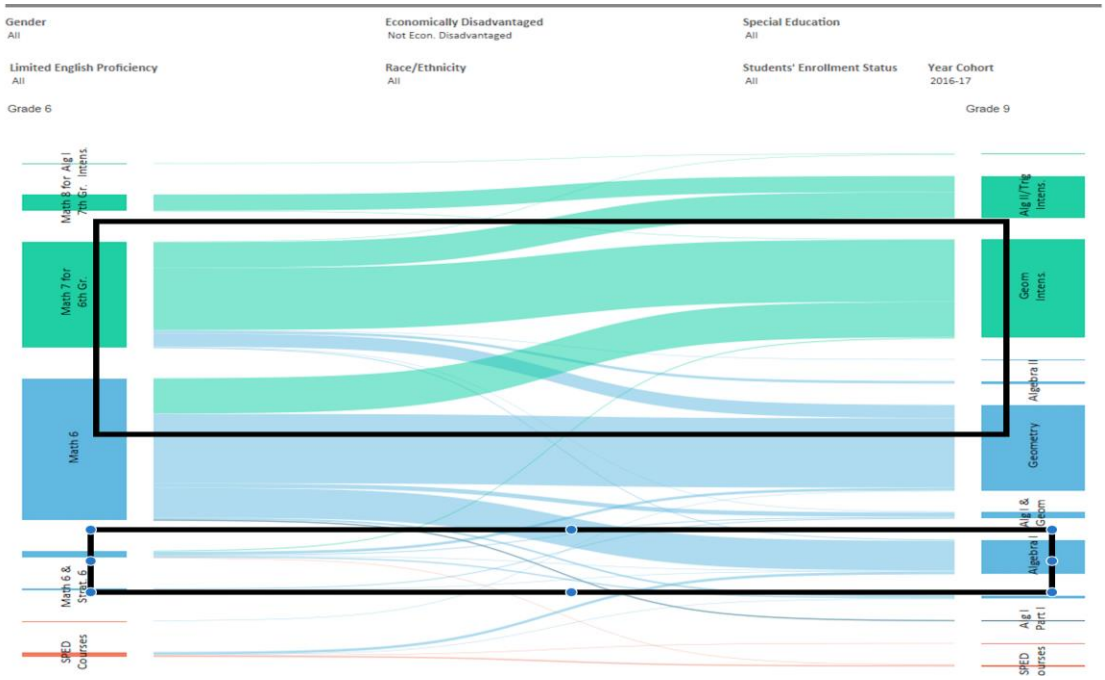


Figure 27: EL Students Grades 8 - 12 [2-Level Dashboard 2016-17]

- Non-EL students have greater enrollment in college-level courses in high school. However, enrollment in other classes have comparable trajectories.
- Some EL students who take Strategies in Grade 8 take college-level courses by Grade 12.
- No dually-identified students take college-level courses in high school (EL and Non-EL).

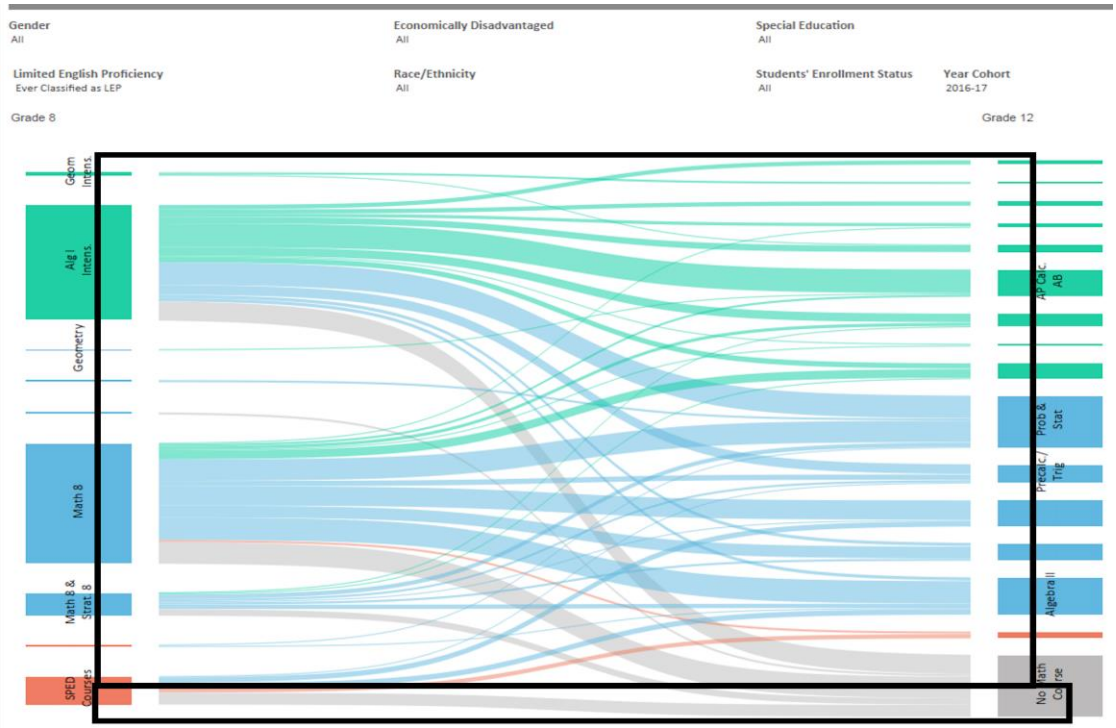
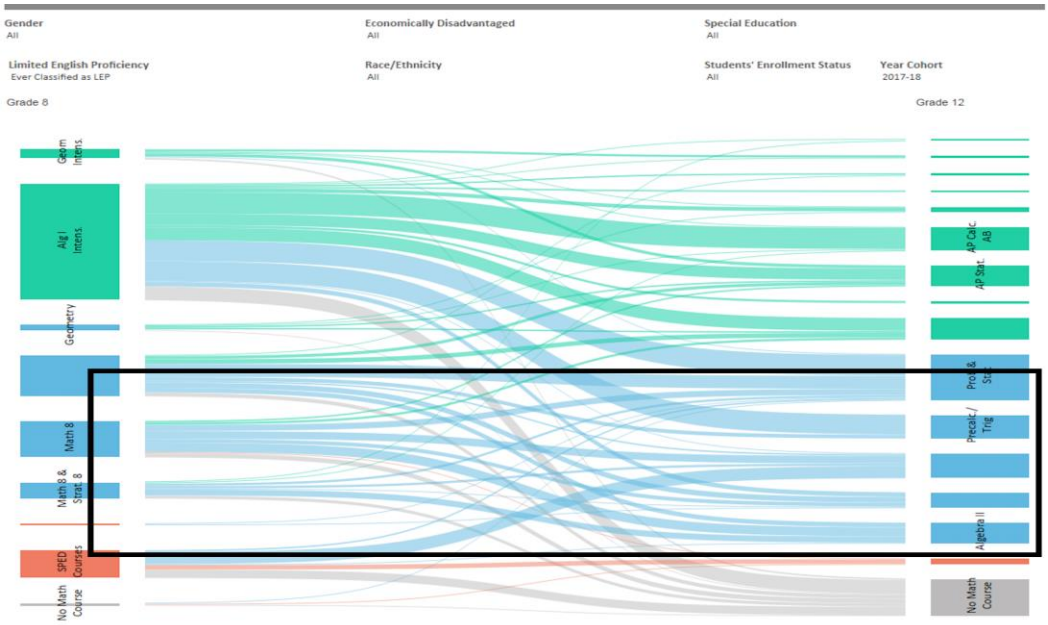


Figure 28: EL Students Grades 8 - 12 [2-Level Dashboard 2017-18]

- EL students are more likely to take college-level courses in high school than Non-EL students when taking Mathematics 8, Mathematics 8 with Strategies, or Special Education Mathematics in Grade 8.
- EL students who are enrolled in high school credit courses in middle school take college-level courses by Grade 12 in a comparable manner as Non-EL students.



Figures 29 through 31 provide more detailed information about the progress and patterns of Black/African American students in APS.

Figure 29: Black Students Grades 6 - 9 [2-Level Dashboard 2016-17]

- Few Black students are enrolled in the most intensified mathematics course in Grade 6.
- Far fewer Black students take an intensified course by Grade 9.
- About 1/4 of Black students who take the Jump Start to Algebra summer course move to intensified courses by Grade 9. They are more likely to take intensified courses by Grade 9 than Non-Black students who also take the Jump Start summer course.

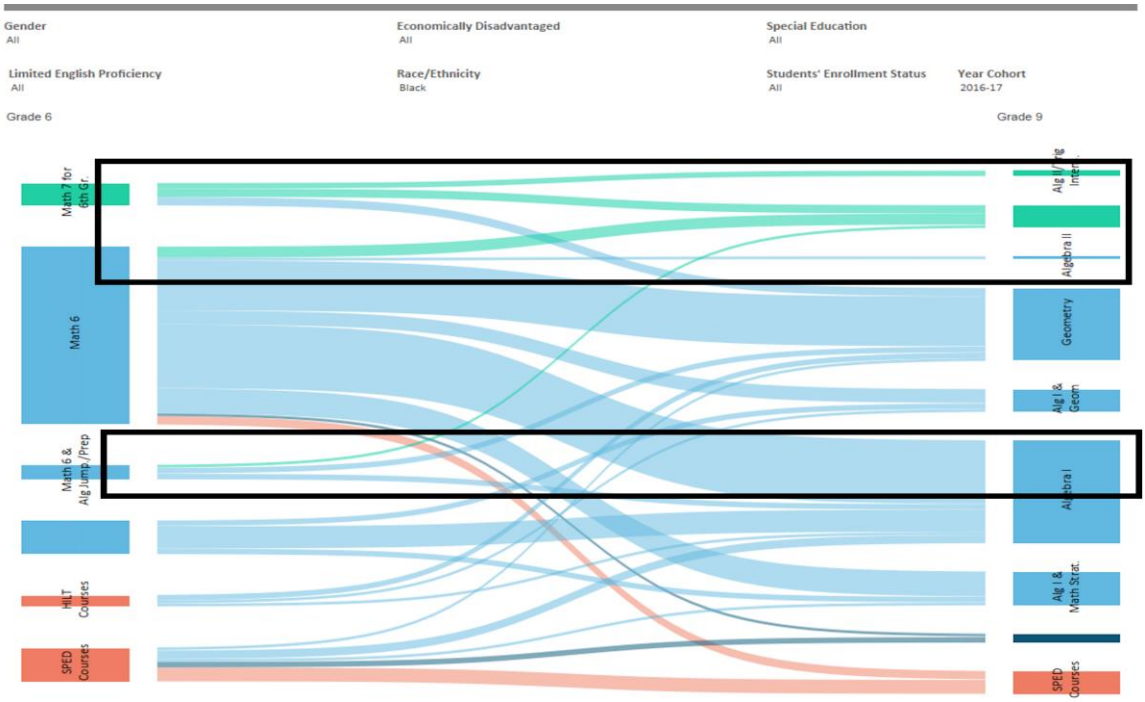


Figure 30: Black Students Grades 8 - 12 [2-Level Dashboard 2016-17]

- Black students who take a Strategies course enroll in college-level courses by senior year at a higher percentage than Non-Black peers.

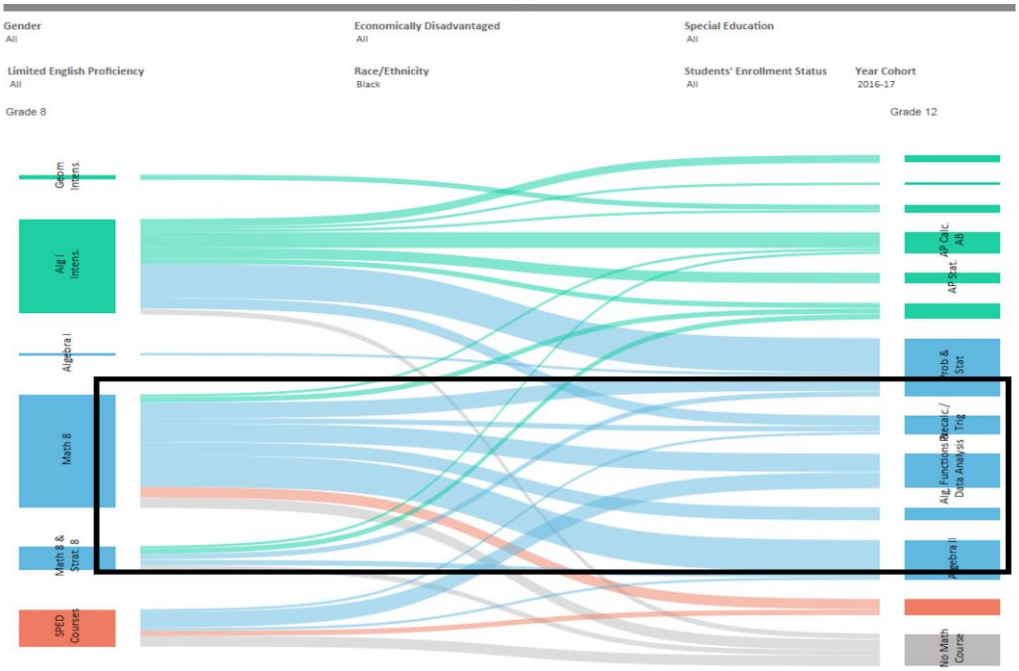
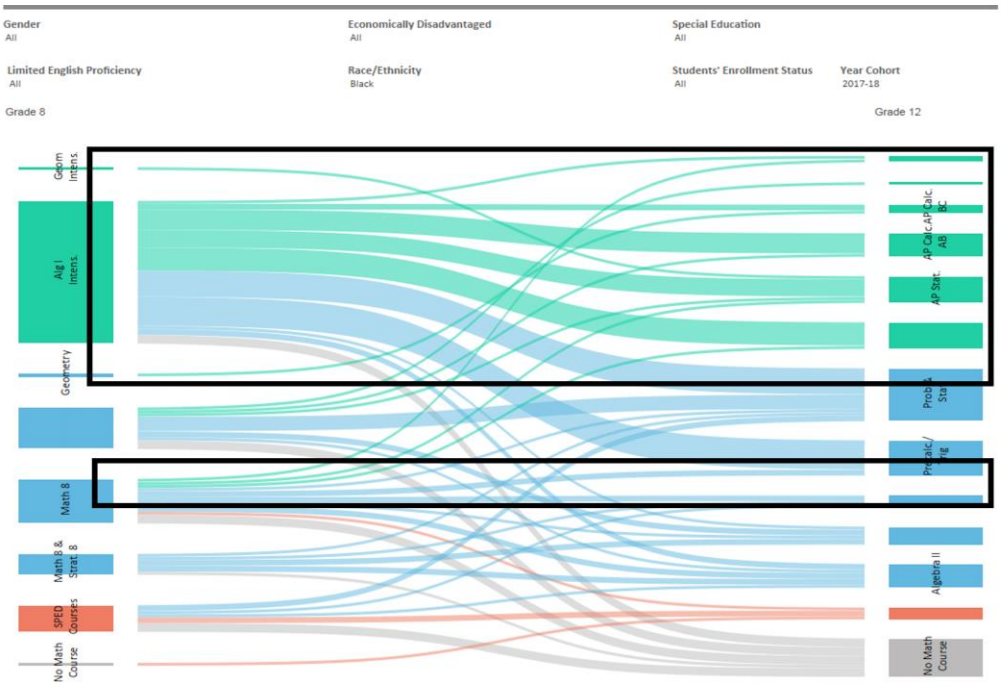


Figure 31: Black Students Grades 8 - 12 [2-Level Dashboard 2017-18]

- Most Black students who begin intensified courses in Grade 8 take a college-level course by Grade 12, which is comparable to Non-Black peers.
- Black students who enroll in Jump Start to Algebra in the summer are more likely to take intensified courses by Grade 9 than Non-Black students.



Figures 32 through 36 below provide more detailed information about the progress and patterns of students with an Economically Disadvantaged Status.

Figure 32: Economically Disadvantaged Students Grades 6 - 8 [2-Level Dashboard 2016-17]

- The top box highlights that about 1/3 of the students in Mathematics 7 for 6th Graders in 6th grade end up in Intensified Geometry in 8th grade.
- Almost half of the students who take Mathematics 6 (or Mathematics 6 with a summer school enrichment program after) complete Algebra I in 8th grade.

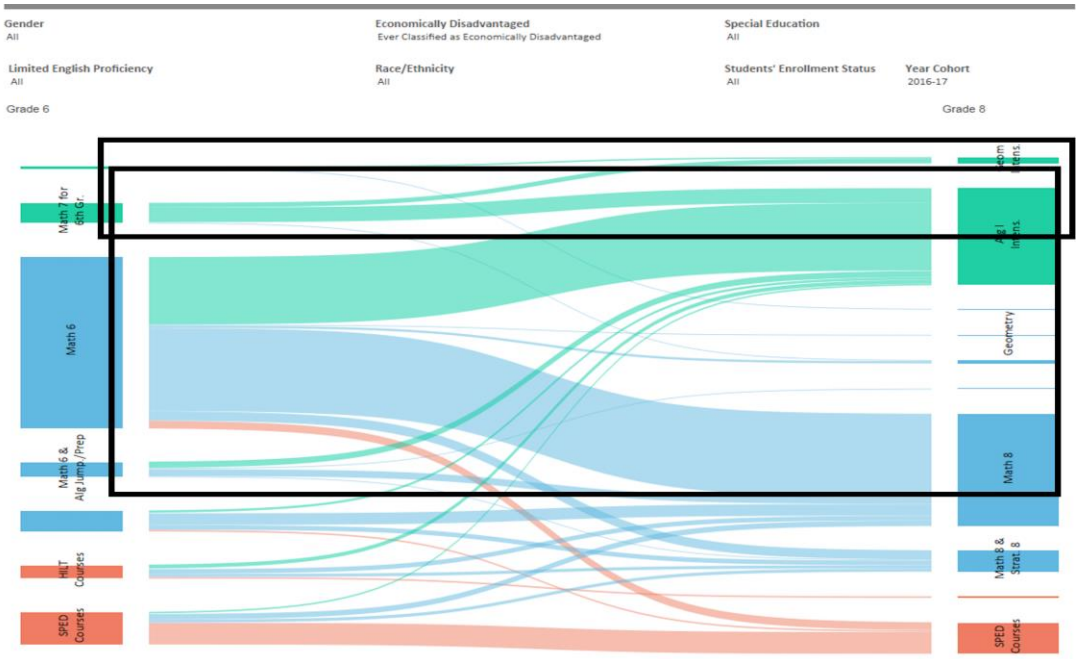


Figure 33: Economically Disadvantaged Students Grades 6 - 9 [2-Level Dashboard 2016-17]

- Some Economically Disadvantaged students who take Mathematics 6 in 6th grade, a grade level course, end up taking Algebra II/Trig, Intensified in 9th grade, but far fewer than their Non-Economically Disadvantaged peers.
- Some Economically Disadvantaged students take an even more advanced course than their Non-Economically Disadvantaged peers; hitting Intensified Algebra II in Grade 9.
- Of the students identified as Economically Disadvantaged and also identified as an EL or as a Special Education student in 6th grade, more than half, take a high school credit course in 9th grade. Some take Geometry.

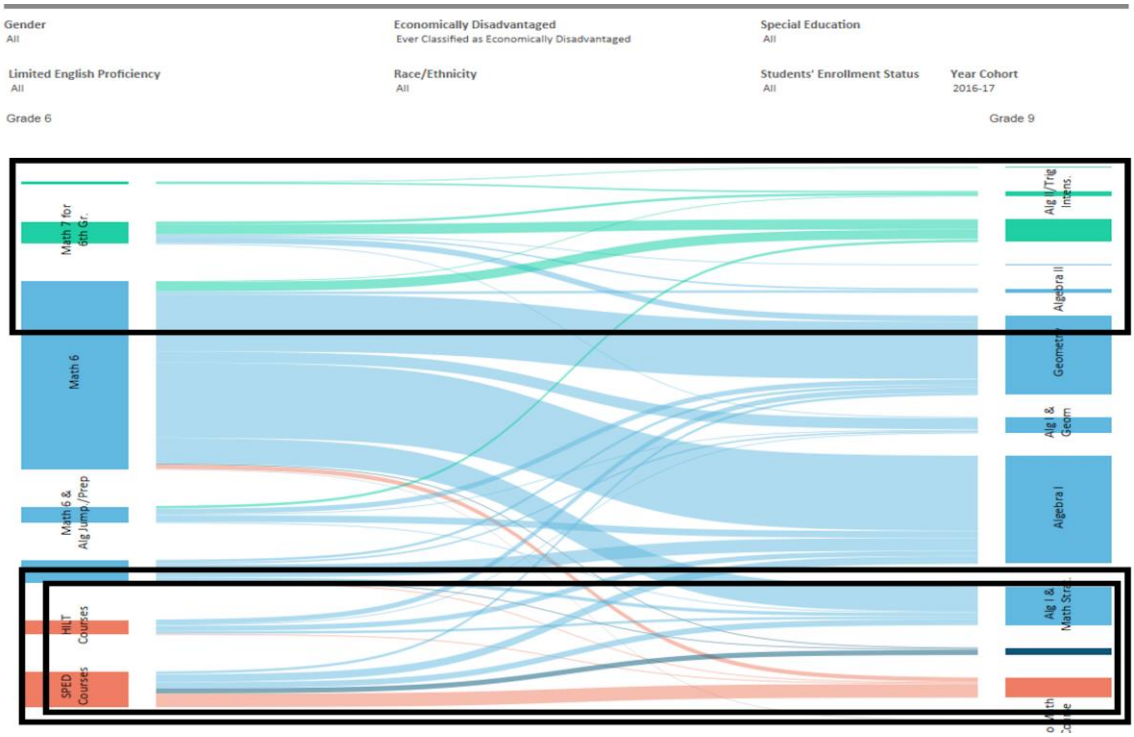


Figure 34: Non-Economically Disadvantaged Students Grades 6 - 9 [2-Level Dashboard 2016-17]

- Approximately 1/6 of the students taking Mathematics 7 for 6th Graders in 6th grade take Geometry in 9th grade.
- A large group of students taking Mathematics 6 in 6th grade take Intensified Geometry in 9th grade.
- Geometry is technically a tenth-grade course. Intensified Geometry is advanced.

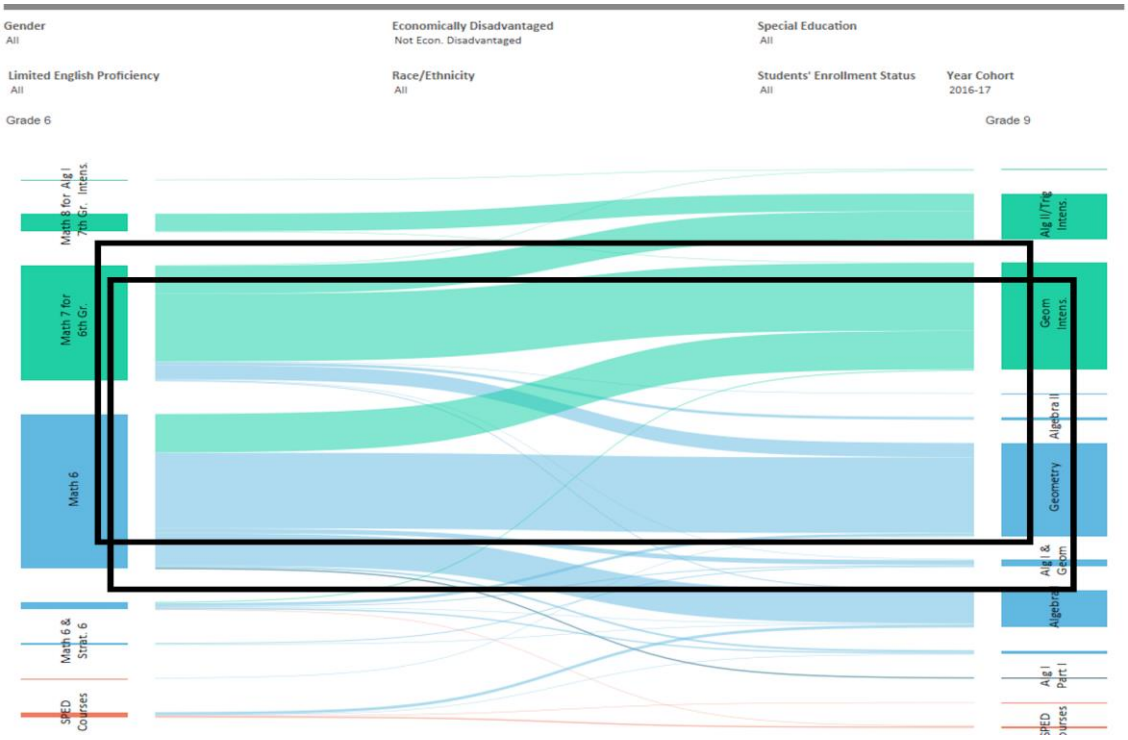


Figure 35: Economically Disadvantaged Students Grades 8 - 12 [2-Level Dashboard 2016-17]

- Approximately 20 percent of Economically Disadvantaged students taking Intensified Algebra I in 8th grade do not take a mathematics course in 12th grade. This is also true of other 8th grade courses. About 20 percent of Economically Disadvantaged students do not take a mathematics class in their senior year.
- There are Economically Disadvantaged students who take Mathematics 8 in 8th grade who move on to take college credit courses in Grade 12 - including Calculus.
- In addition, some students who require a Strategies course in Grade 8 go on to take a college-level course in high school.
- The paths that Non-Economically Disadvantaged students take from Algebra I Intensified mirror what happens with the Economically Disadvantaged students.

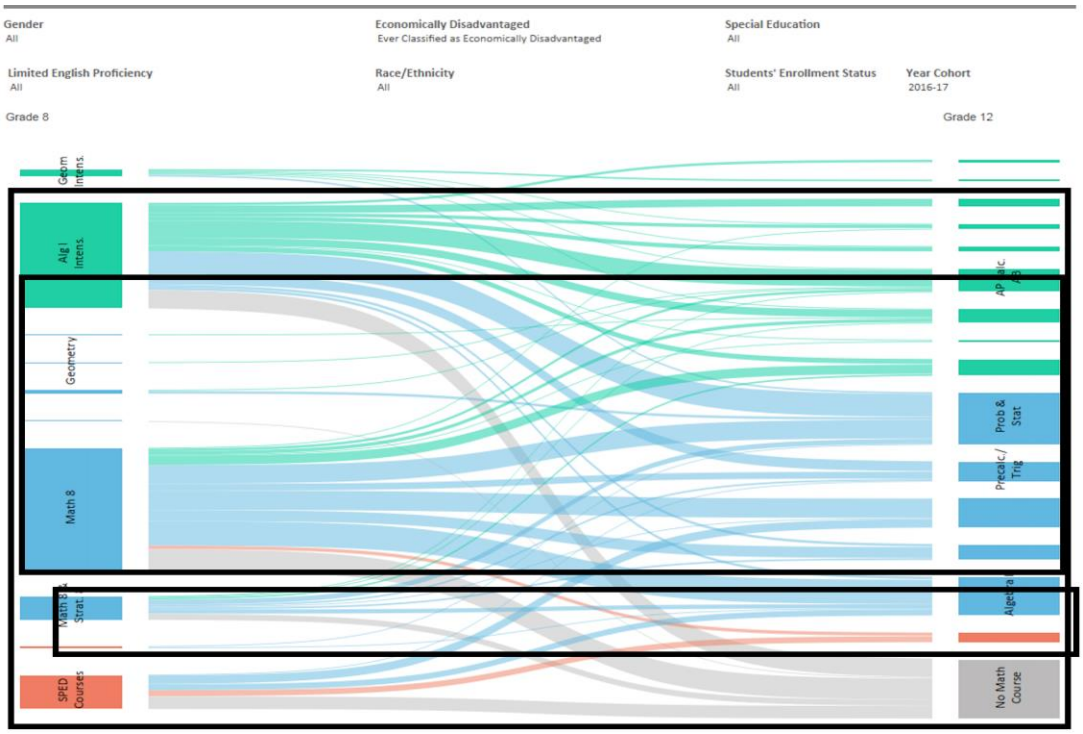
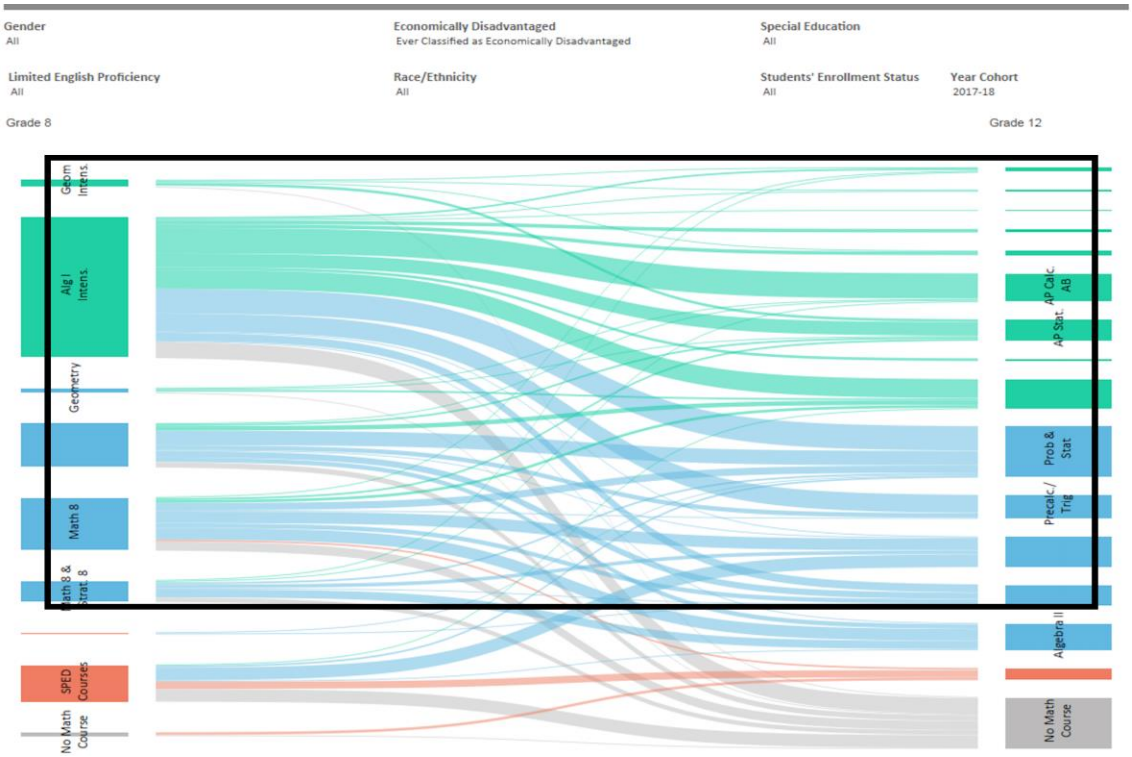


Figure 36: Economically Disadvantaged Students Grades 8 - 12 [2-Level Dashboard 2017-18]

- Economically Disadvantaged students who begin high school courses in middle school are comparable to Non-Economically Disadvantaged students though most take Algebra in middle school.
- Some Economically Disadvantaged students in Mathematics 8 end up in college-level courses by 12th grade.



Figures 37 through 40 provide more detailed information about the progress and patterns of Students with a Disability.

Figure 37: Students with a Disability Grades 6 - 9 [2-Level Dashboard 2016-17]

- The greatest variance in intensified courses is among Students with a Disability (SWD)
- More than half of students who are in Special Education classes in 6th grade take grade-level credit-bearing classes in the 9th grade.

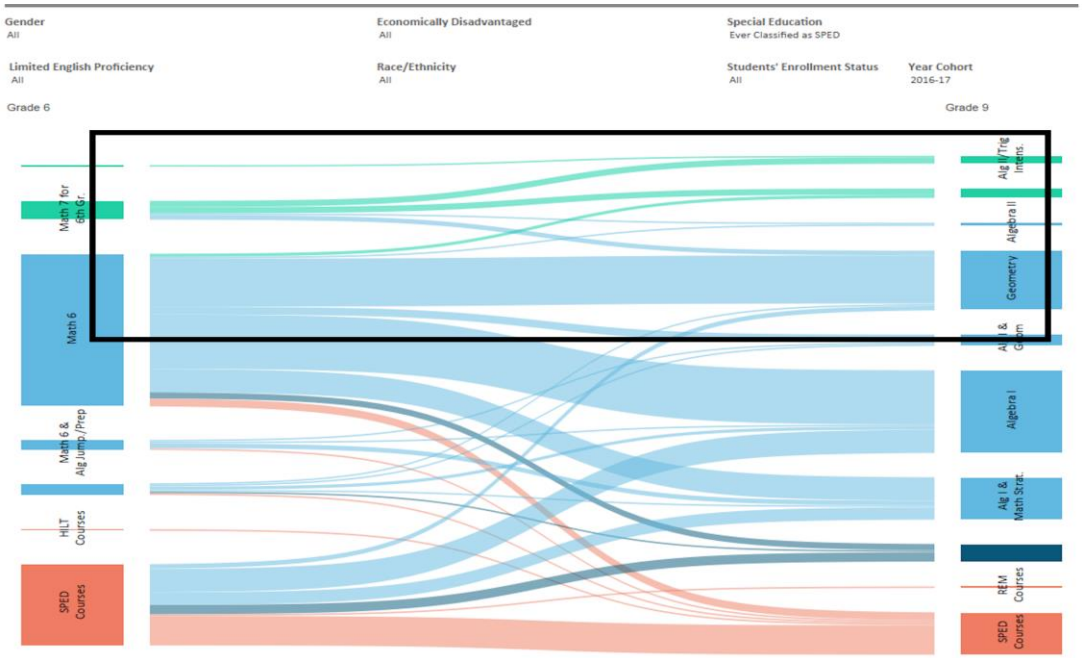


Figure 38: Students with a Disability Grades 8 - 12 [2-Level Dashboard 2016-17]

- Special Education students who begin high school mathematics in middle school have a higher rate of not taking mathematics all four years.
- Some SWD who take Mathematics 8 with Strategies are still able to take a college-level course in high school.

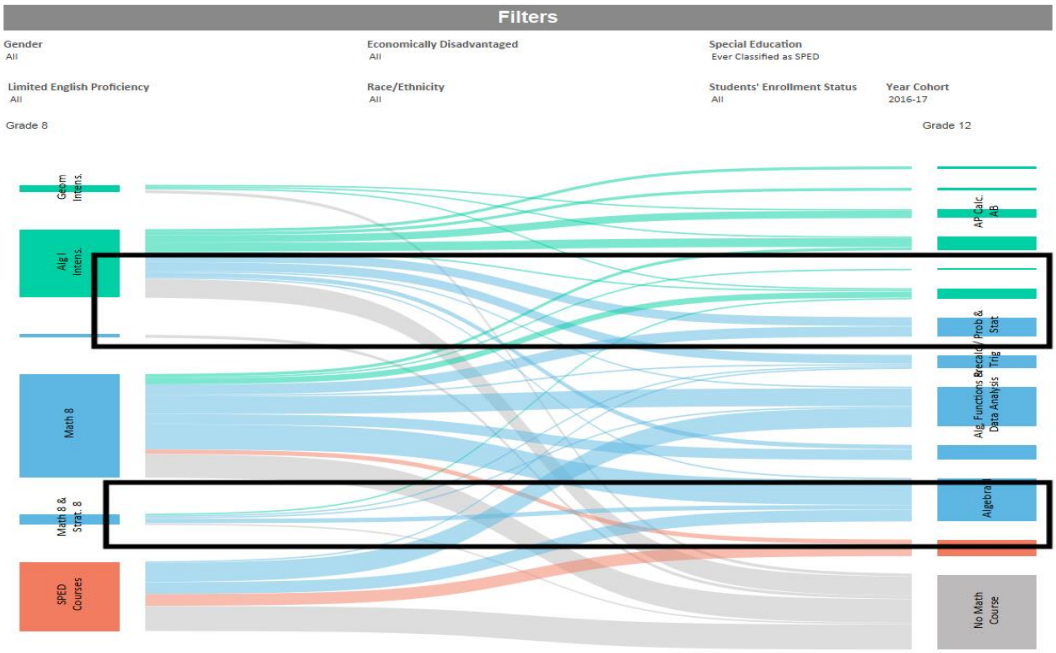


Figure 39: Students with a Disability Grades 6 - 9 [2-Level Dashboard 2017-18]

- SWD are much less likely to enroll in intensified courses by Grade 9 compared to their peers but more than half are enrolled in above grade-level courses (Geometry and above) by Grade 9.

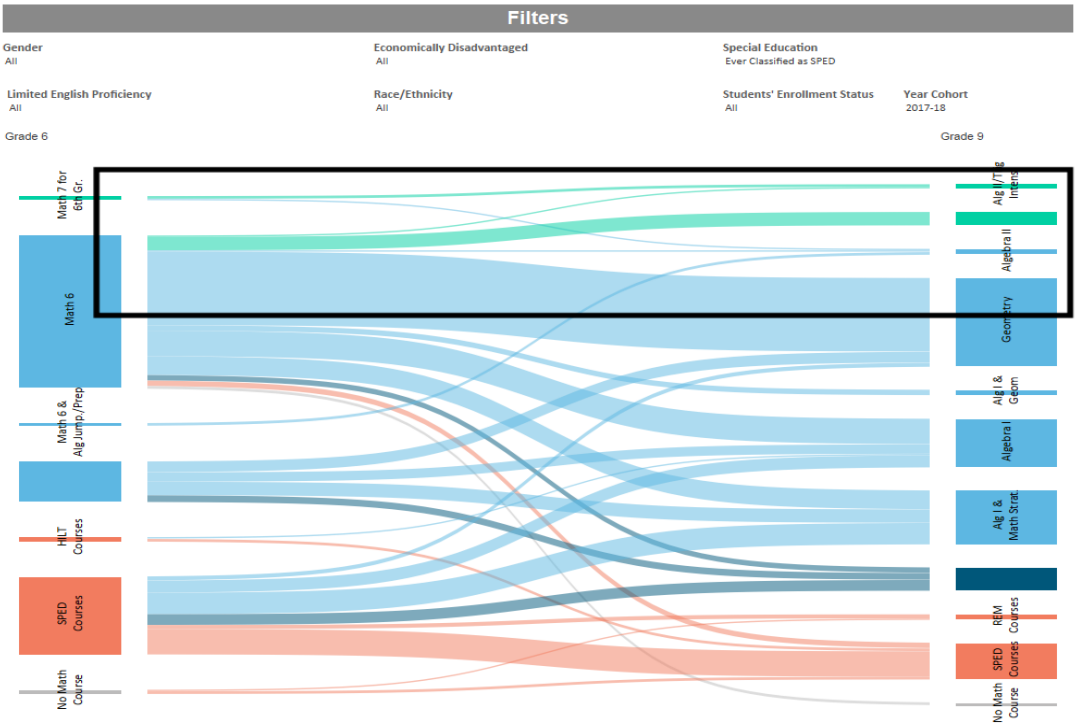
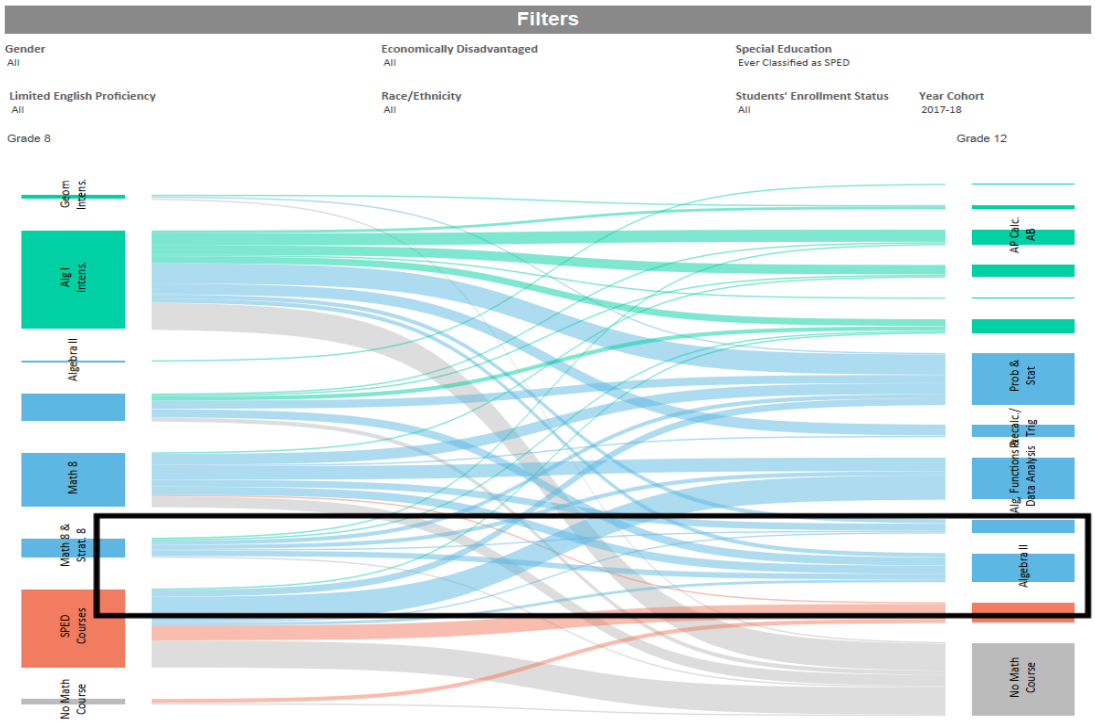


Figure 40: Students with a Disability Grades 8 - 12 [2-Level Dashboard 2017-18]

- SWD are, overall, less likely to enroll in college-level courses by Grade 12. SWD who are enrolled in Special Education courses in Grade 8 or Mathematics 8 with Strategies are more likely to enroll in college-level courses before leaving high school than Non-SWD peers enrolled in Mathematics 8 with Strategies.



Enrollment Data

Enrollment in Advanced Mathematics Coursework

Representation of student groups in advanced mathematics courses in **Middle School** has been consistent between 2015-16 and 2017-18. In general, female and male participation in advanced coursework is proportionate to their overall population in the school. Asian students also participate in advanced coursework in proportion to their overall population in the school. Non-disadvantaged students, Non-SWD students (students with no disability), and White students all participate in advanced coursework at a higher proportion than their overall population at the school. During that time period, the following groups have been underrepresented in advanced coursework:

- Economically disadvantaged students, by 12-14 percent.
- Students with disabilities, by 10-12 percent.
- Black students, by 3 percent.
- Hispanic students, by 8-9 percent.

Figures 41 – 43, show the proportion of **Middle School** students displayed by demographic group enrolled in advanced mathematics coursework compared to their overall enrollment (from the 2015-16 school year through the 2017-18 school year).

Figure 41: MS Mathematics Advanced Course Enrollment Data by Ethnicity

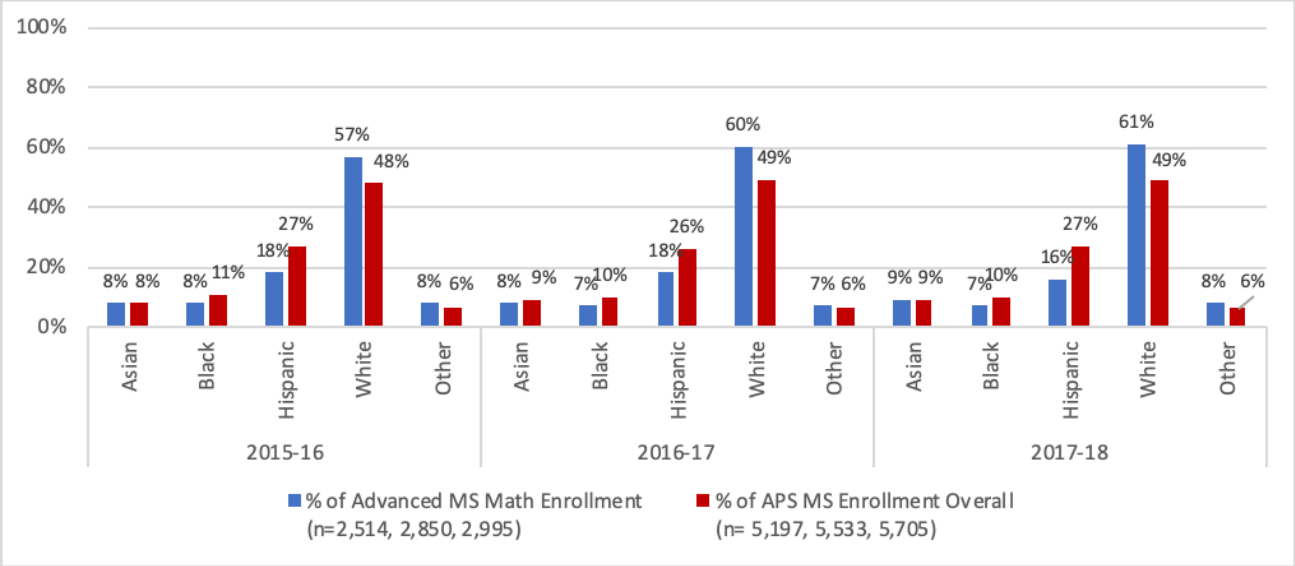


Figure 42: MS Mathematics Advanced Course Enrollment by Socioeconomic Status

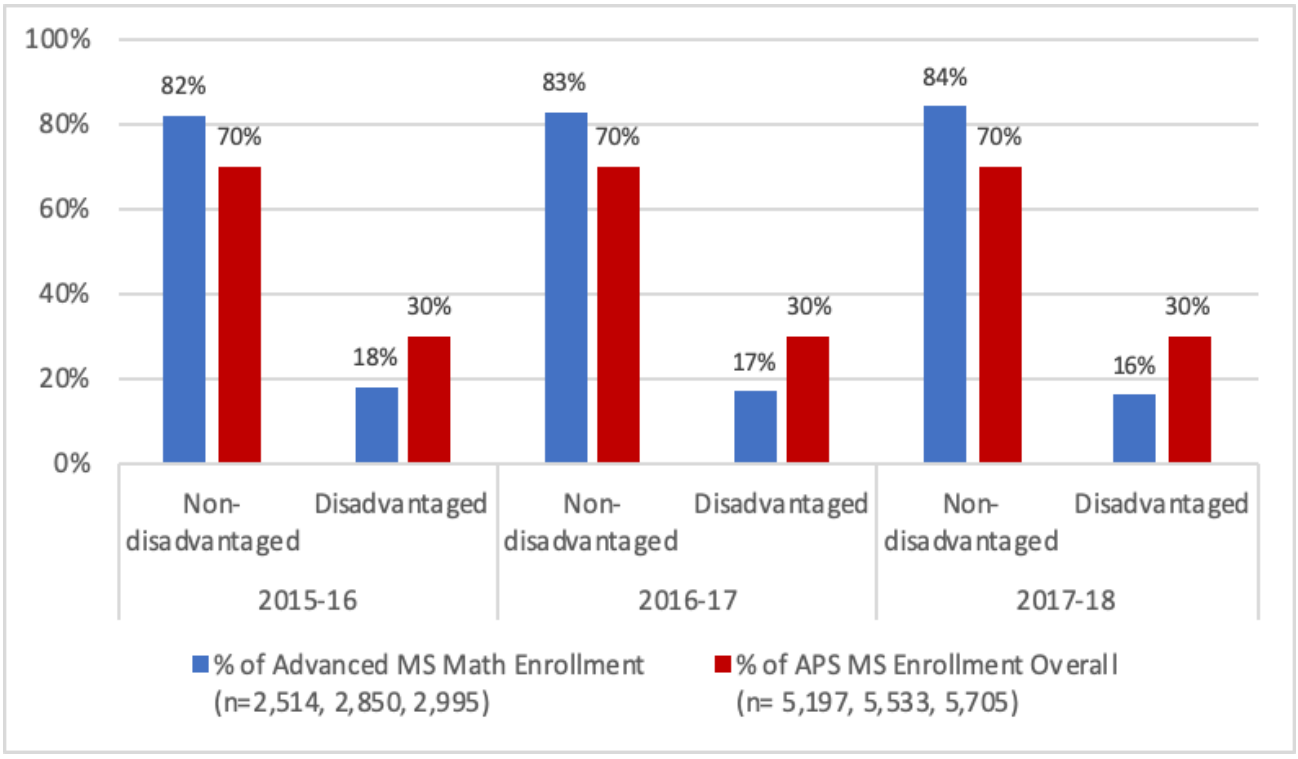
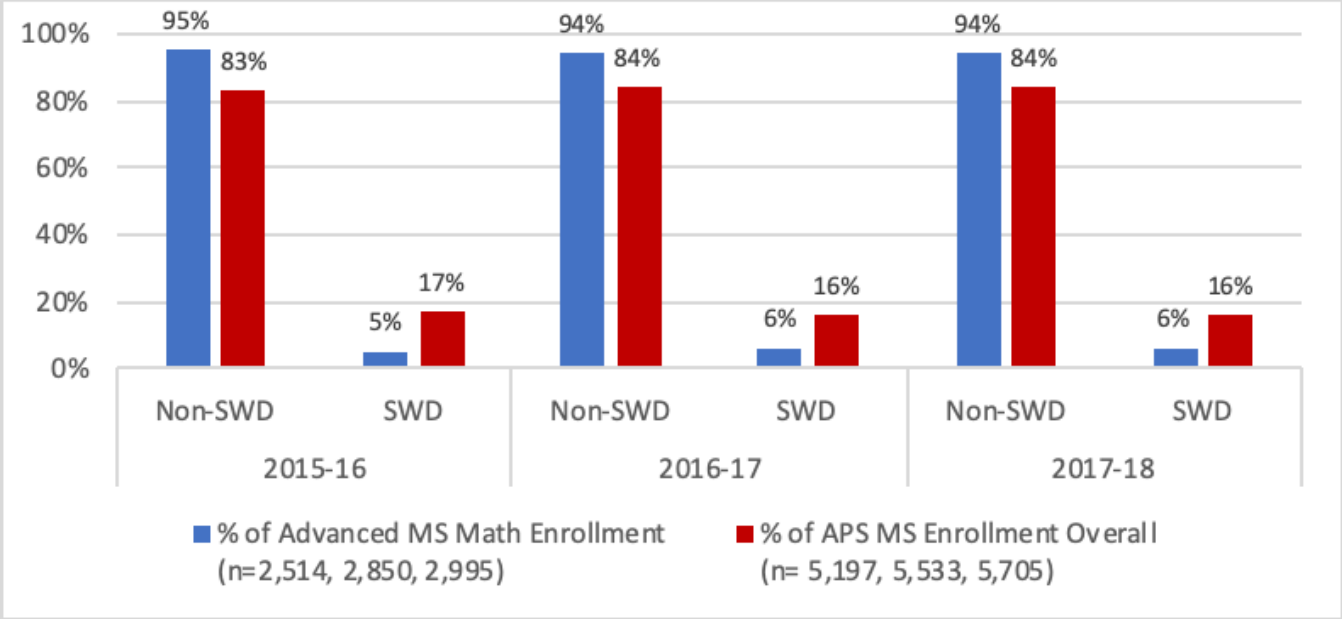


Figure 43: MS Mathematics Advanced Course Enrollment by Student with a Disability Status



Figures 44 – 46, show the proportion of High School students by demographic group enrolled in advanced mathematics coursework compared to their overall enrollment (from the 2015-16 school year through the 2017-18 school year).

At the high school level, representation of student groups in advanced mathematics courses has also been consistent between 2015-16 and 2017-18. Female participation in advanced coursework is higher than their overall population in in the school. Asian students participate in advanced mathematics coursework at a proportion equal to or slightly higher than their overall population in the school division. Non-disadvantaged students, Students with no disability, and White students enroll in advanced mathematics classes at a proportion higher than their overall population at the school. During that time the following student groups were underrepresented in advanced coursework when compared to the overall population:

- Male students, by 4-5 percentage points.
- Economically disadvantaged students, by 15-20 percentage points.
- Students with disabilities, by 13-14 percentage points.
- Black students, by 6-7 percentage points.
- Hispanic students, by 19-20 percentage points.

In each category of underrepresented students, there is an increase in the level of that underrepresentation in advanced mathematics coursework from middle school to high school. Male students, who had enrollment equal to overall population in the school at the middle school level, saw a 4-5 percent drop from their overall population in the school at the high school level. Economically disadvantaged students and Hispanic students see the most significant difference

between their enrollment in advanced mathematics coursework and their population in the school. Students with disabilities and Black students also see lower enrollment in advanced coursework.

Figure 44: HS Mathematics Advanced Course Enrollment by Ethnicity

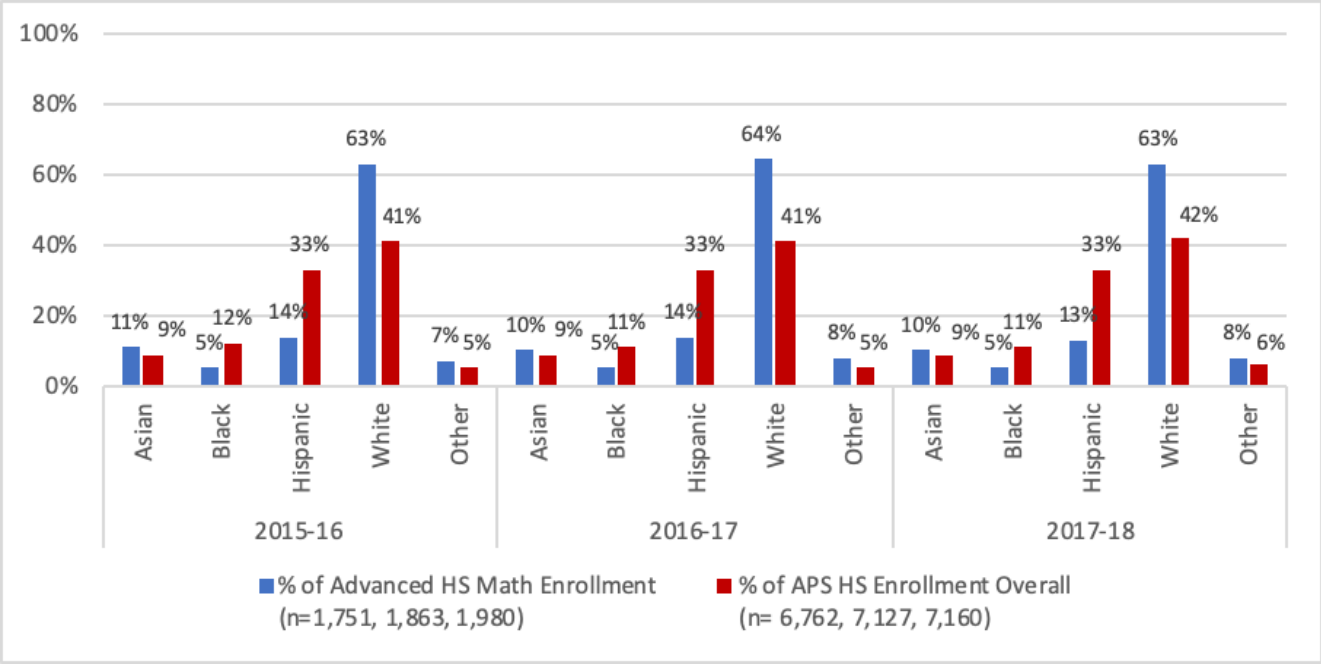


Figure 45: HS Mathematics Advanced Course Enrollment by Socioeconomic Status

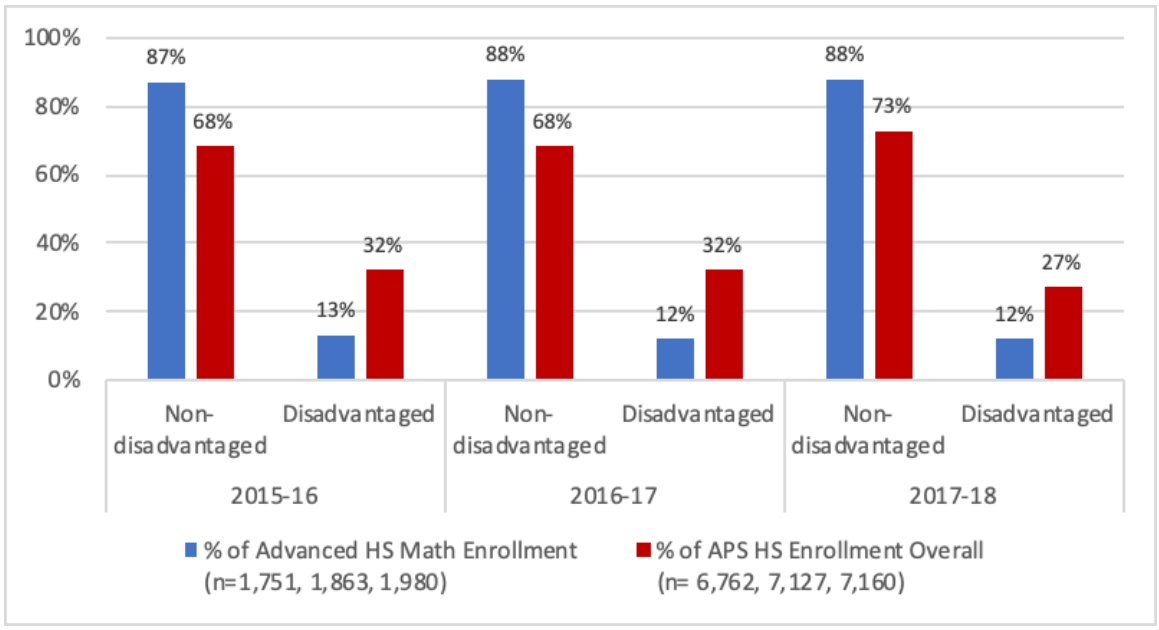
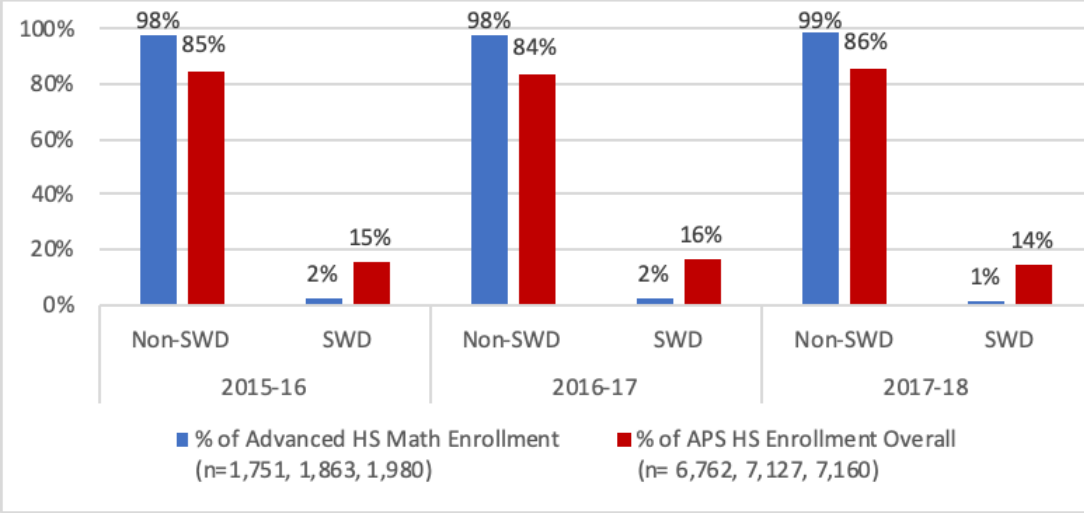


Figure 46: HS Mathematics Advanced Course Enrollment by SWD Status



More enrollment data with demographic breakdowns are included in **Appendix C2**.

Enrollment of English Learners in Advanced Mathematics Coursework

A separate analysis examined enrollment of English Learners in advanced mathematics coursework at the middle and high school levels. Figures 45 and 46 display those results.

- At the middle school level, representation of English Learners in advanced mathematics coursework is consistent with their overall proportion of the general population in the 2015-16 school year. Over the next two school years, however, English Learners' enrollment in advanced classes is 3-4 percent lower than their overall population in the school.
- At the high school level, English Learners are enrolled in advanced mathematics coursework at rates lower than their overall high school enrollment by 3-4 percent. As a student's ELP Level (English Language Proficiency) increases, their enrollment in advanced mathematics courses also increases. At both the middle school and high school levels, students in the Proficient category, who have completed the EL program, participate in advanced classes at significantly higher rates than students who are in the EL program.

* This analysis includes enrollment data for English learners at these high ELP levels, as well as former English learners, classified as proficient.

Figure 47: Mathematics Advanced Course Enrollment of English Learners in MS

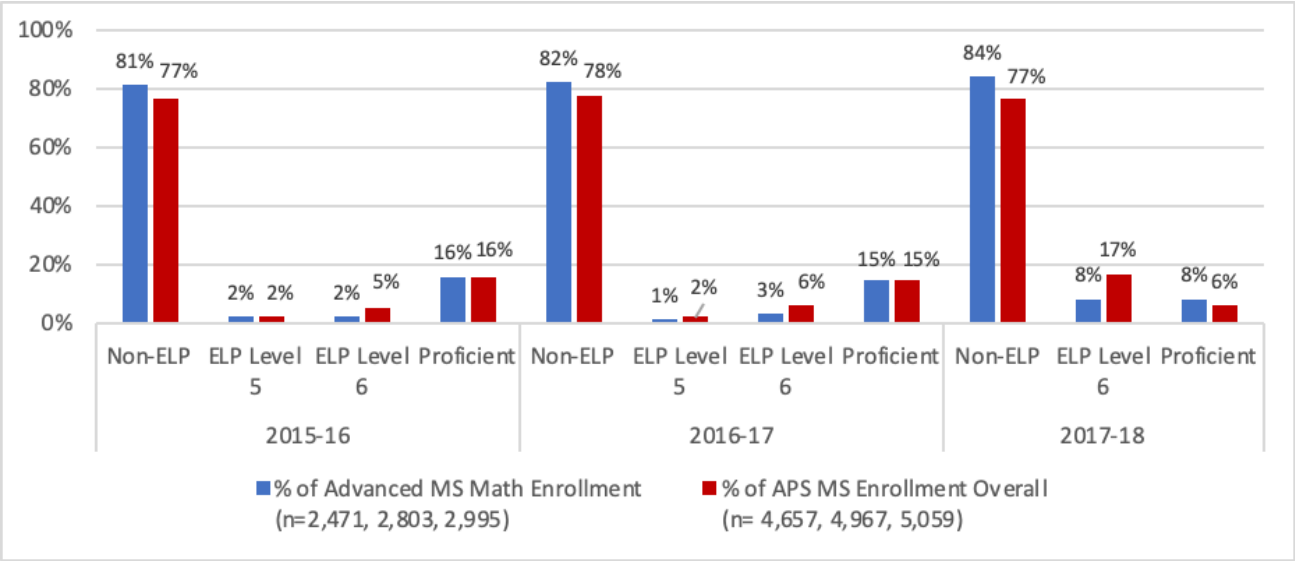
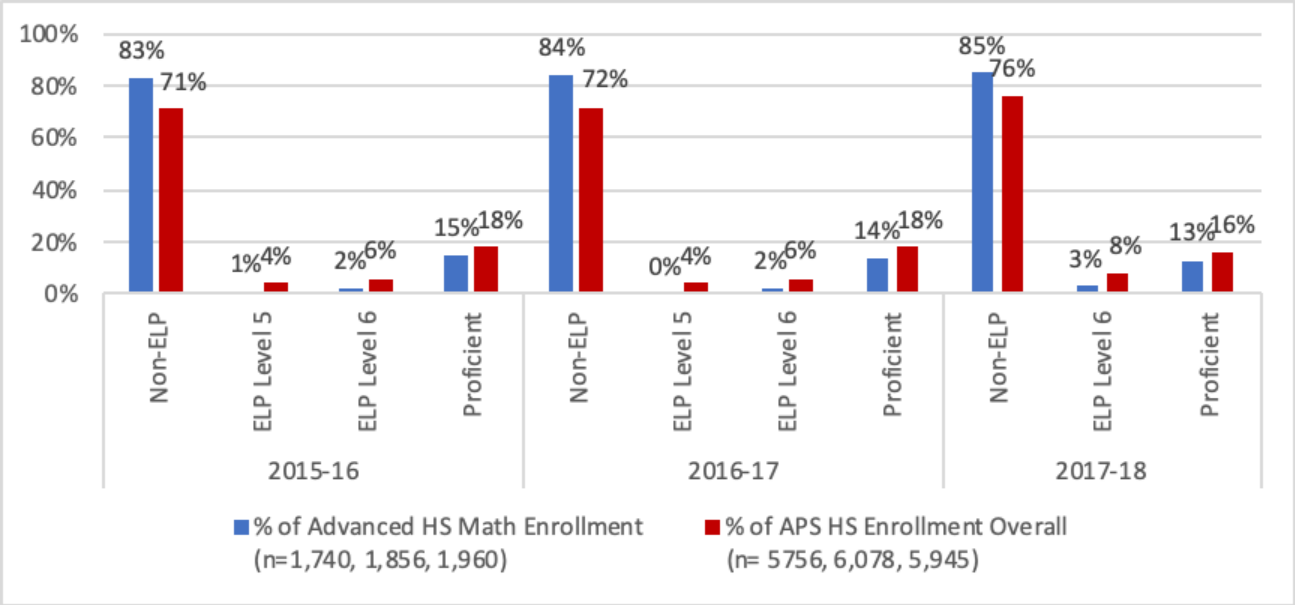


Figure 48: Mathematics Advanced Course Enrollment of English Learners in HS



TEACHER PREPARATION

From teacher responses to questions on the Mathematics Survey, observations of teachers reported on the Mathematics Observation Tool, and data regarding teacher endorsements, the Mathematics Office can evaluate teacher preparedness for teaching mathematics to APS students. Specific areas of focus are teacher content knowledge and their ability to effectively help students learn the mathematics curriculum.

Figures 49 – 51 show teacher confidence in their ability to effectively teach mathematics content as well as the confidence in their ability to differentiate instruction for students through mathematics extension or remediation.

- Elementary teachers are very confident in their ability to effectively teach mathematics content. They are equally confident in their ability to remediate instruction. However, they are less confident in their ability to challenge students through extension at 51 percent. Six percent indicated they have no confidence in their ability to extend mathematics content.
- Middle school teachers are also very confident in their ability to effectively teach mathematics content at 90 percent. They are also very confident in their ability to remediate instruction. However, only 45 percent of middle school teachers report confidence in their ability to enhance student depth of learning through extension of mathematics content. Ten percent indicate they have no confidence in their ability to extend mathematics content.
- High school teachers have the highest levels of confidence in all areas. They report the highest level of confidence in their ability to effectively teach mathematics content - at 91 percent. Eighty-six percent report they are very confident in their ability to remediate instruction. Fifty-eight percent report they are very confident in their ability to extend instruction for their students.

Figure 49: Overall Confidence in Effectively Teaching Mathematics Content

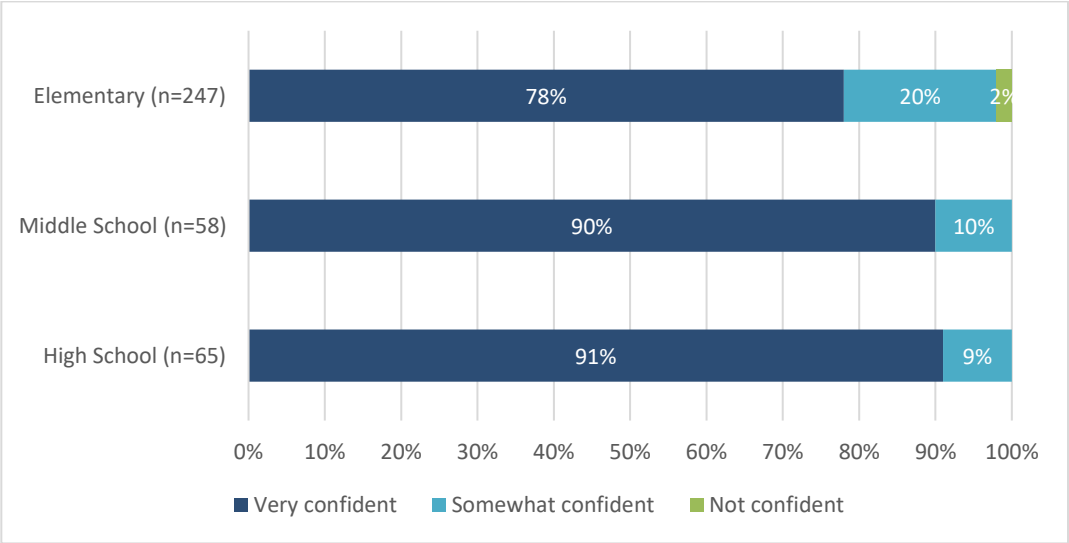


Figure 50: Confidence in Ability to Extend Mathematics Content

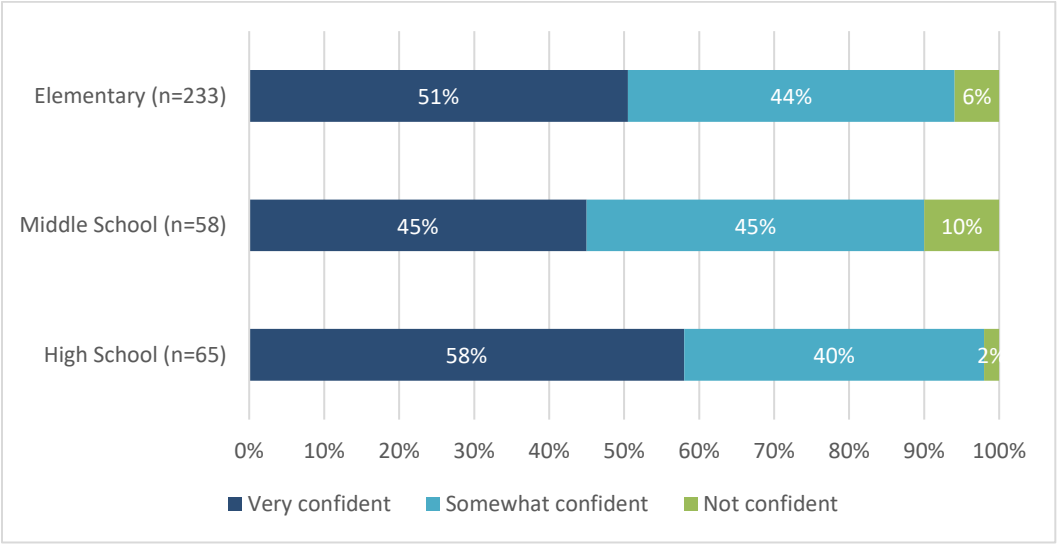
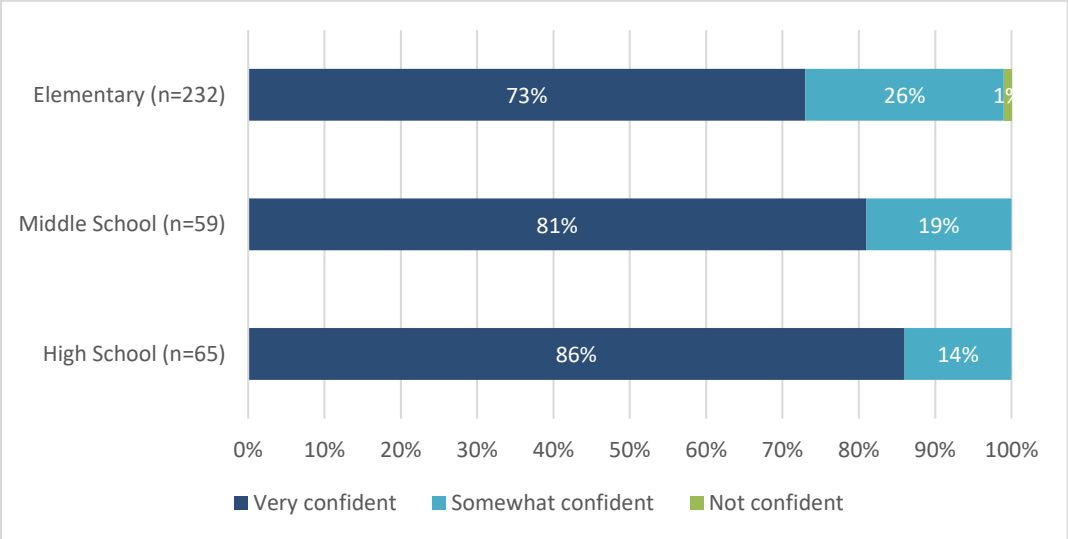


Figure 51: Confidence in Ability to Remediate Mathematics Content



The following two tables show the responses from teachers when asked about the ways they differentiate instruction for their students who need extra support or extra challenge in mathematics. When students need additional support, teachers indicate that they most commonly will use the following strategies: flexible grouping, modifying classwork, using manipulatives, one-on-one time, additional instruction and re-teaching. These are similar for regular classroom teachers, EL teachers and Special Education teachers. EL and SPED teachers also use visuals.

Table 19: In what ways do you differentiate for students who need extra challenge in mathematics (Elementary teachers)?

Classroom teacher (n=331 responses)		Special Education teacher (n=61 responses)		English Learner teacher (n=41 responses)	
Response	Percent	Response	Percent	Response	Percent
Small groups/flexible grouping	32%	Small groups/flexible grouping	18%	Small groups/flexible grouping	20%
Individualized lesson/modified assignments or tasks	11%	Individualized lesson/modified assignments or tasks	18%	Use of manipulatives	20%
Use of manipulatives	10%	Use of manipulatives	12%	Language support	12%
Re-teaching lessons	6%	Visuals	7%	Visuals	12%
One on one instruction	5%	Multiple instructional strategies	5%	Re-teaching lessons	7%
Provide extra time for task/assignment	5%	Provide extra time for task/assignment	5%	Other (several single responses were reported including: additional instruction, scaffolding, using data, working with a peer etc…)	30%
Additional instruction	4%	Graphic organizers	3%		
Math coach	3%	Preview upcoming lesson	3%		
Multiple instructional strategies	2%	Read aloud	3%		
Visuals	2%	Scaffolding	3%		
Using data/formative assessment to guide instruction	2%	Using technology	3%		
Working with a peer	2%	Working with a peer	3%		
Allowing student choice	2%	Other (several single responses were reported including: additional instruction, scaffolding, using data, working with a peer etc…)	16%		
Using mathematics games	2%				

Multiple learning centers	2%				
Scaffolding assignments/tasks	1%				
Language support	1%				
Using technology	1%				
Other	6%				

Table 20: In what ways do you differentiate for students who need extra challenge in mathematics (Elementary teachers)?

Classroom teacher (n=258 responses)		**Special Education teacher (n=25 responses)**		**English Learner teacher (n=11 responses)**	
Response	Percent	Response	Percent	Response	Percent
Small groups	23%	Modify assignment to challenge students	28%	Extensions to lesson	27%
Modify assignment to challenge students	21%	Independent project/task	20%	Ask students to explain their work	18%
Extensions to lesson	19%	Small groups	16%	Modify assignment to challenge students	18%
Higher level thinking/Problem solving tasks	9%	Extensions to lesson	12%	Other (several single responses were reported including: groups, higher level thinking, games etc…)	32%
Independent project/task	6%	Other (several single responses were reported including: choice, higher level thinking, games etc…)	24%		
Allowing student choice	5%				
Working with a RTG	4%				
Ask students to explain their work	3%				
Using technology or software	3%				
Compacting/Adjust pace	2%				
Games	2%				
Other	3%				

Table 21 below measures middle school teacher confidence in their ability to teach mathematics courses taught at the middle school level, not only the class they are currently teaching, but other mathematics courses as well, including classes they may have taught in the past or have not taught at all. Table 22 measures high school teacher confidence in their ability to teach mathematics courses at the high school level. The responses reveal classroom experience with a variety of mathematics courses as well as familiarity and confidence with mathematics content. Teachers use that experience and confidence to help students make connections with the skills they are learning in the present class as well as making connections to previous and future learning.

- At the middle school level, teachers are very confident with the content they are presently teaching. Responses show that teachers have a wide variety of experience teaching different courses. For teachers who do not have experience teaching Mathematics 6, 7, or 8, they still have confidence in their ability to teach that class effectively. As classes become more advanced, (Algebra l, Algebra l Intensified, Geometry Intensified) teachers who have not taught the class have lower confidence.
- At the high school level, responses show similar trends. Teachers are very confident with the content they are presently teaching. They have experience with and confidence in their ability to teach a variety of mathematics courses. For teachers who have not taught a particular mathematics course, there is a lower confidence in their ability to teach that course effectively.

Table 21: Level of Confidence in Effectively Teaching Content of Mathematics Classes Offered in Middle School

Course	Experience with Course	Very Confident	Somewhat Confident	Not Confident
6	I am currently teaching this class. (n=19)	89%	11%	0%
	I have taught this class in the past. (n=13)	77%	15%	8%
	I have never taught this class. (n=8)	75%	25%	0%
7	I am currently teaching this class. (n=23)	96%	4%	0%
	I have taught this class in the past. (n=18)	83%	11%	6%
	I have never taught this class. (n=6)	50%	33%	17%
8	I am currently teaching this class. (n=11)	100%	0%	0%
	I have taught this class in the past. (n=22)	82%	18%	0%
	I have never taught this class. (n=7)	0%	71%	29%
Algebra I	I am currently teaching this class. (n=8)	75%	25%	0%
	I have taught this class in the past. (n=12)	92%	8%	0%
	I have never taught this class. (n=14)	7%	64%	29%
Algebra I Intensified	I am currently teaching this class. (n=8)	88%	13%	0%
	I have taught this class in the past. (n=6)	100%	0%	0%
	I have never taught this class. (n=20)	15%	45%	40%
Intensified Geometry	I am currently teaching this class/I have taught this class in the past. (n=5)	100%	0%	0%
	I have never taught this class. (n=22)	14%	32%	55%

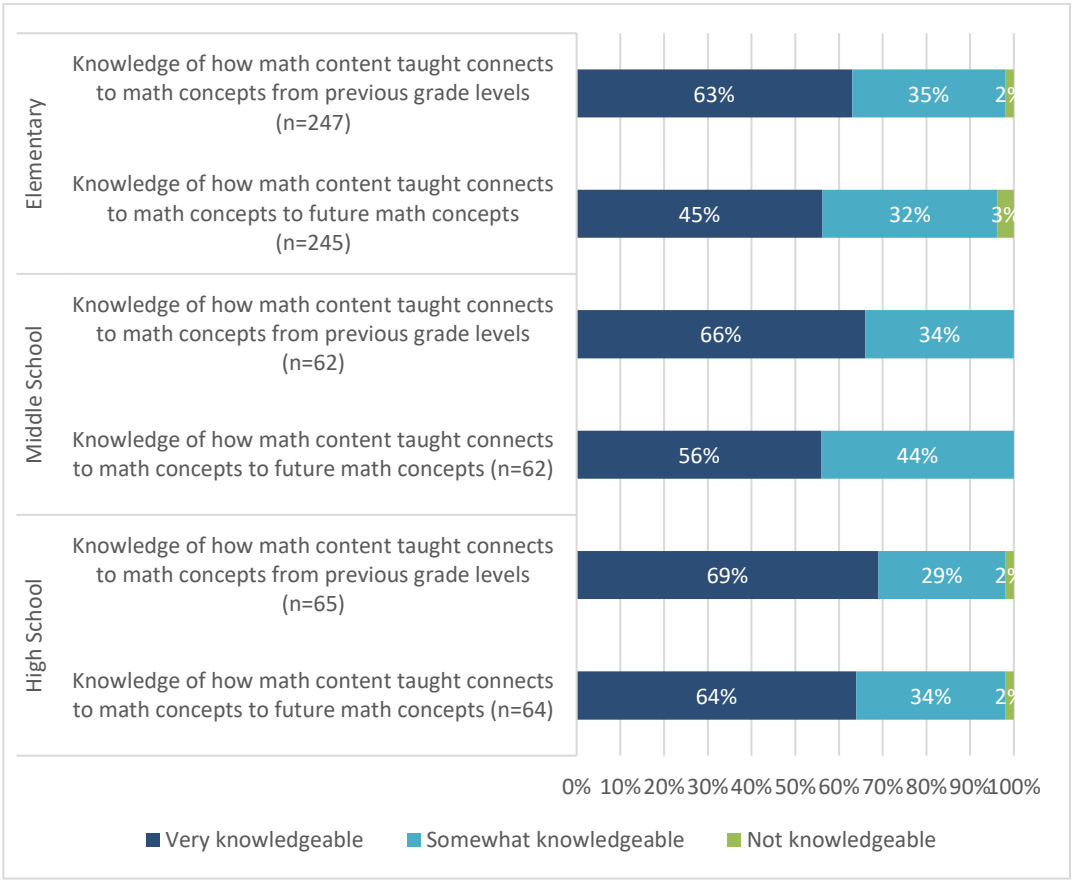
Table 22: Level of Confidence Effectively Teaching Content of Mathematics Classes Offered in High School

Course	Experience with Course	Very Confident	Somewhat Confident	Not Confident
Math Foundations/General Math/Pre-Algebra	I am currently teaching this class. (n=10)	70%	30%	0%
	I have taught this class in the past. (n=29)	86%	7%	7%
	I have never taught this class.(n=19)	53%	37%	11%
Algebra I (Part I, Part II, Algebra I, Block, Strategies) or AFDA	I am currently teaching this class. (n=26)	96%	4%	0%
	I have taught this class in the past. (33)	97%	3%	0%
	I have never taught this class. (5)	60%	20%	20%
Geometry (Principles, Strategies, Geometry)	I am currently teaching this class. (n=14)	93%	7%	0%
	I have taught this class in the past. (n=28)	82%	14%	4%
	I have never taught this class. (n=9)	22%	78%	0%
Intensified Geometry	I am currently teaching this class./I have taught this class in the past. (n=12)	100%	0%	0%
	I have never taught this class. (n=35)	43%	51%	6%
Algebra II and/or Algebra II Strategies	I am currently teaching this class. (n=19)	100%	0%	0%
	I have taught this class in the past. (n=25)	84%	16%	0%
	I have never taught this class. (n=9)	22%	44%	33%
Algebra II Intensified	I am currently teaching this class. (n=6)	100%	0%	0%
	I have taught this class in the past. (n=7)	86%	14%	0%
	I have never taught this class. (n=33)	52%	33%	15%
Math for Liberal Arts (MTH 151/152)	I am currently teaching this class. (n<5)	*	*	*
	I have taught this class in the past. (n<5)	*	*	*
	I have never taught this class. (n=40)	35%	38%	28%
MAT or Pre-calculus	I am currently teaching this class. (n=13)	100%	0%	0%
	I have taught this class in the past. (n=16)	81%	19%	0%
	I have never taught this class.(n=19)	16%	47%	37%
Prob/Stat or AP Statistics	I am currently teaching this class. (n=7)	71%	29%	0%
	I have taught this class in the past. (n=9)	89%	11%	0%
	I have never taught this class. (n=32)	6%	53%	41%
Calculus and above	I am currently teaching this class. (n=12)	100%	0%	0%
	I have taught this class in the past. (n=7)	100%	0%	0%
	I have never taught this class. (n=31)	16%	39%	45%

It is important that teachers encourage and help students to make connections with prior knowledge. This makes the new knowledge more meaningful and memorable. Similarly, demonstrating how material they are presently learning is connected to future learning helps build a meaningful foundation for that future learning. The figure below shows teacher knowledge of how the mathematics content they are teaching is related to previous courses as well as how the mathematics content is connected to future mathematics courses.

- Across grade levels, teachers indicate they are Very or Somewhat Knowledgeable about mathematics content connections between previous and future mathematics concepts at almost 100 percent. At all levels, teachers are more confident in their ability to make connections with previous learning than future learning. Knowledge in both areas, however, is high at all levels.

Figure 52: Teacher Knowledge of How Mathematics Content Taught Connects to Previous Mathematics Concepts and Connects to Future Mathematics Concepts



As of the 2017-18 data, students who are enrolled in non-credit bearing mathematics courses are being taught by teachers who are endorsed in Mathematics, English as a Second Language, or have dual certification in both Mathematics and English as a Second Language. No students are being taught by a teacher without at least one of those endorsements.

Table 23: Number of Enrollments in Non-credit Bearing Mathematics Course by Teacher Endorsement Type

Teacher Endorsement Type	2015-16 (n=176)	2016-17 (n=356)	2017-18 (n=356)
Math	80%	72%	86%
English as a Second Language	19%	12%	8%
Both Math and English as a Second Language	0%	16%	6%
Neither Math or English as a Second Language	1%	0%	0%

Content academies are professional development opportunities that focus on improving content understanding and creating differentiated activities with the goal of enhancing student outcomes. The following tables show the participation rates for elementary mathematics teachers in content academies and the impact of their participation on their confidence and content knowledge. Just over half of all elementary mathematics teachers attended a content academy. Of those who participated, 55 percent felt the content academy was very effective in increasing their confidence and content knowledge; 41 percent it was somewhat effective; and 4 percent felt it was just a little effective. Only 1 percent of those who attended the content academy stated that the academy was not at all effective in increasing their confidence and content knowledge.

Table 24: Mathematics Content Academy Participation (Elementary Teachers)

Teachers who have participated in content academy? (Elementary Teachers)		
Responses	**Responses**	**%**
Yes	137	55%
No	110	45%
Total Responses	**247**	

Table 25: Mathematics Content Academy Effectiveness (Elementary Teachers)

Effectiveness of participation on increasing your confidence and content knowledge (Elementary Teachers, have participated in a content academy)		
Responses	**Responses**	**%**
Very effective	75	55%
Somewhat effective	56	41%
Just a little effective	5	4%
Not at all effective	1	1%
Total Responses	**137**	

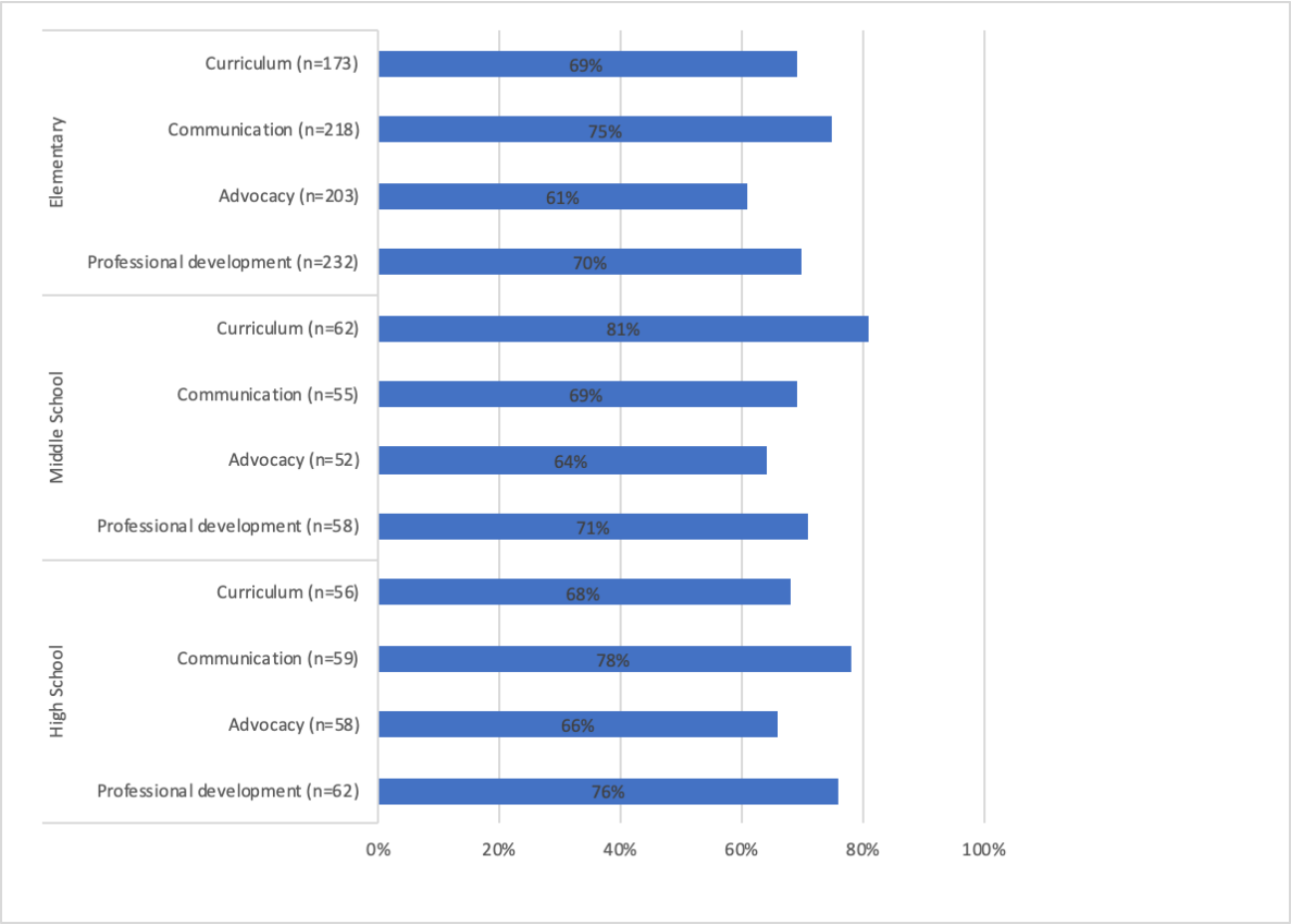
RESOURCES

Division-Level and County-Level Support

In the Mathematics Survey, teachers provide feedback regarding school, division-level, and county-level support. This support includes things such as professional development opportunities, mathematics coaches, resources, communication, and curriculum support. Figure 34 shows the satisfaction level with division-level support by grade level. Overall satisfaction levels are high, every area indicating satisfaction levels above 60 percent.

- At the elementary level, communication and professional development have the highest levels of satisfaction with scores at 75 and 70 percent respectively. Advocacy has the lowest score with a 61 percent.
- At middle school level, curriculum support receives the highest score of 81 percent, followed by professional development at 71 percent. Advocacy has the lowest satisfaction rate of satisfaction at 64 percent.
- At the high school level, communication and professional development also have the highest levels of satisfaction with scores of 78 and 76 percent respectively. Advocacy has the lowest rating at 66 percent.

Figure 53: Satisfaction with Division-Level Support from the Main Office



The chart below pertains to the availability and use of county-level resources. The figures are a combination of the reported daily and weekly frequency of use of county resources (i.e., 67 percent of elementary teachers use the county-created curriculum guide daily or weekly).

- While Elementary school teachers utilize all county-provided resources at relatively high levels, they use other outside resources the most often at 74 percent.
- Middle school teachers also utilize available county-provided resources at relatively high levels. They also use other outside resources the most often indicating they use those resources daily or weekly 79 percent of the time.
- High school teachers utilize county-provided resources at the lowest levels. They use county-purchased curriculum resources, such as textbooks, the most at 44 percent. They are most likely to use other outside resources.

Table 26: Availability and Use of Resources

	Elementary School	Middle School	High School
County-created curriculum guide	67% (2% never use)	77% (2% never use)	16% (30% never use)
County-purchased curriculum resources (textbooks, manipulatives, supplemental texts)	62% (7% never use)	46% (5% never use)	44% (22% never use)
County-purchased technology (DreamBox, Reflex Math, Gizmos)	73% (18% never use)	67% (2% never use)	25% (39% never use)
County-recommended outside resources (VDOE enhanced scope and sequence)	49% (11% never use)	51% (5% never use)	21% (19% never use)
Other outside resources	74% (9% never use)	79% (3% never use)	54% (6% never use)

Tables 27 through 29 show teacher satisfaction with available resources for differentiation. Across grade levels, teachers indicate they are at least Somewhat Satisfied with the available resources. The level of dissatisfaction at the elementary and middle school levels is relatively high at 34 and 35 percent respectively.

Table 27: Level of Satisfaction with Resources for Differentiation (Elementary Teachers)

Responses	Responses	%
Very Satisfied	34	14%
Somewhat Satisfied	116	47%
Somewhat Dissatisfied	58	24%
Very Dissatisfied	24	10%
N/A – I don't need support in this area.	1	0%
N/A – I don't receive this type of support from the Math Office.	9	4%
I don't know	4	2%
Total Responses	**246**	

Table 28: Level of Satisfaction with Resources for Differentiation (Middle School Teachers)

Responses	Responses	%
Very Satisfied	2	3%
Somewhat Satisfied	26	43%
Somewhat Dissatisfied	15	25%
Very Dissatisfied	6	10%
N/A – I don't need support in this area.	2	3%
N/A – I don't receive this type of support from the Math Office.	7	11%
I don't know	3	5%
Total Responses	**61**	

Table 29: Level of Satisfaction with Resources for Differentiation (High School Teachers)

Responses	Responses	%
Very Satisfied	14	22%
Somewhat Satisfied	24	37%
Somewhat Dissatisfied	7	11%
Very Dissatisfied	4	6%
N/A – I don't need support in this area.	2	3%
N/A – I don't receive this type of support from the Math Office.	5	8%
I don't know	9	14%
Total Responses	**65**	

Role of Mathematics Coaches

Mathematics coaches provide educational support to classroom teachers in a variety of ways from assistance with classroom interventions to delivery of professional development. At present, all elementary schools have a part time mathematics coach assigned to them. Each middle school has one mathematics coach and the high schools do not have a mathematics coach. Teachers were asked to provide information about the role of mathematics coaches at their schools.

Table 30: Role of Mathematics Coach at the Elementary Level

Which of the following do you provide in your role as math coach? Select all that apply. (Elementary Teachers, math coach) n=21		
Responses	**Responses**	**%**
Distribution of math information	19	90%
Assistance with finding resources	21	100%
Assistance with planning	19	90%
Support for math instruction	21	100%
Support for interventions	18	86%
Analysis of data	20	95%
Delivery of professional development	18	86%
None	0	0%
Other (Please specify)	5	24%
Total Responses	**141**	
Multiple answers per participant possible. Percentages added may exceed 100 since a participant may select more than one answer for this question.		

Table 31: Role of Mathematics Coach at the Middle School Level

Which of the following do you provide in your role as math coach? Select all that apply. (Middle School Teachers, math coach) n=6		
Responses	**Responses**	**%**
Distribution of math information	6	100%
Assistance with finding resources	6	100%
Assistance with planning	6	100%
Support for math instruction	5	83%
Support for interventions	6	100%
Analysis of data	6	100%
Delivery of professional development	6	100%
None	0	0%
Other (Please specify)	0	0%
Total Responses	**41**	
Multiple answers per participant possible. Percentages added may exceed 100 since a participant may select more than one answer for this question.		

SECTION 2: FINDINGS

Evaluation Question #2: What were the outcomes for the targeted population?

STUDENT OUTCOMES

Kindergarten and Grade 1 Assessments -

The Kindergarten and Grade 1 Assessment is a countywide tool used at the beginning of the year to establish baseline data on student understanding of current grade level mathematics and an end of year K-1 test designed to assess mastery of objectives at the end of the year.

- Table 30 shows the overall APS results of the Kindergarten and Grade 1 Assessment. Average scores at the beginning of the year for both Kindergarten and Grade 1 are between 49 and 51 percent and consistently demonstrate growth of 40 percent over the course of the school year.
- Scores disaggregated by gender bear similar results.
- Scores disaggregated by EL Status show that EL students have lower Beginning of Year scores by approximately 20 percent. Despite the fact that EL student overall gains are actually higher than Non-EL students, End of Year scores for EL students are generally about 10 percent lower than Non-EL students.
- Scores disaggregated by Disadvantaged Status show that Beginning of the Year scores are approximately 20 percent lower than Non-Disadvantaged student scores. End of Year scores rise an incredible 45 to 50 percent. However, scores are still 10 percent below Non-Disadvantaged students.
- Scores disaggregated by SWD Status show that Beginning of the Year scores are 15 to 20 percent lower than Non-SWD students. SWD and Non-SWD students both have a consistent 40 percent increase in scores on the End of Year assessment.
- Overall, the Kindergarten and Grade 1 Assessments indicate that at the earliest levels of education, students are seeing significant and consistent gains in their mathematics aptitude. EL, SWD, and Disadvantaged students also see significant gains. Those gains result in a narrowing of the achievement gap, but, in general, a 10 percent gap still remains.

Table 32: Average Kindergarten and Grade 1 Beginning and End of Year Assessment Scores

Grade	2014-15				2015-16				2017-18			
	BOY		EOY		BOY		EOY		BOY		EOY	
	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score
K	2,036	51%	2,135	91%	2,001	51%	2,136	91%	2,049	49%	2,145	90%
1	2,039	48%	2,100	89%	2,013	49%	2,131	89%	2,024	52%	2,030	90%

Table 33: Average Kindergarten and Grade 1 Beginning and End of Year Assessment Scores, by Gender

		2014-15				2015-16				2017-18			
	Group	BOY		EOY		BOY		EOY		BOY		EOY	
		# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score
K	Female	969	50%	1,022	91%	979	51%	1,054	92%	994	49%	1,041	91%
	Male	1,067	51%	1,113	91%	1,022	52%	1,082	91%	1,055	49%	1,104	89%
1	Female	2,039	48%	1,055	88%	970	48%	1,031	89%	1,004	51%	1,000	89%
	Male	1,024	51%	1,044	89%	1,043	50%	1,100	89%	1,020	53%	1,030	90%

Table 34: Average Kindergarten and Grade 1 Beginning and End of Year Assessment Scores, by EL Status

		2014-15				2015-16				2017-18			
	Group	BOY		EOY		BOY		EOY		BOY		EOY	
		# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score
K	Non-EL	1,423	56%	1,459	93%	1,448	57%	1,517	94%	1,458	56%	1,500	93%
	EL	613	37%	678	84%	553	35%	619	86%	591	33%	645	83%
1	Non-EL	1,386	55%	1,425	91%	1,414	55%	1,464	91%	1,445	57%	1,444	92%
	EL	653	35%	674	84%	599	35%	667	84%	570	39%	586	84%

Table 35: Average Kindergarten and Grade 1 Beginning and End of Year Assessment Scores, by Economically Disadvantaged Status

		2014-15				2015-16				2017-18			
	Group	BOY		EOY		BOY		EOY		BOY		EOY	
		# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score
K	Non-Disadvantaged	1,389	56%	1,442	93%	1,399	58%	1,473	94%	1,448	56%	1,505	93%
	Disadvantaged	647	38%	693	85%	602	27%	663	86%	601	33%	640	82%
1	Non-Disadvantaged	1,376	55%	1,437	91%	1,406	55%	1,459	91%	1,423	57%	1,427	92%
	Disadvantaged	663	34%	662	84%	607	34%	672	83%	601	40%	603	84%

Table 36: Average Kindergarten and Grade 1 Beginning and End of Year Assessment Scores, by SWD Status

		2014-15				2015-16				2017-18			
	Group	BOY		EOY		BOY		EOY		BOY		EOY	
		# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score
K	Non-SWD	1,831	52%	1,925	92%	1,782	52%	1,911	92%	1,831	51%	1,927	91%
	SWD	205	37%	210	81%	219	40%	225	83%	218	36%	218	77%
1	Non-SWD	1,803	50%	1,862	90%	1,818	50%	1,930	90%	1,803	53%	1,805	91%
	SWD	236	37%	237	81%	195	36%	201	80%	221	40%	225	81%

Table 37: Average Kindergarten and Grade 1 Beginning and End of Year Assessment Scores, by Ethnicity

Grade		2014-15				2015-16				2017-18			
	Group	BOY		EOY		BOY		EOY		BOY		EOY	
		# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score	# tested	Avg Score
K	Asian	173	49%	193	91%	183	49%	210	90%	188	46%	209	89%
	Black	187	45%	197	89%	190	44%	207	89%	168	45%	182	87%
	Hispanic	551	39%	587	85%	511	38%	542	87%	526	36%	557	83%
	White	988	58%	1,017	94%	979	59%	1,034	94%	998	57%	1,026	93%
	Other	137	54%	141	93%	138	60%	143	94%	169	56%	171	93%

1	Asian	190	52%	202	90%	174	51%	188	89%	178	54%	182	90%
	Black	167	38%	173	84%	183	41%	207	85%	190	47%	190	87%
	Hispanic	565	36%	569	84%	533	35%	571	85%	526	41%	524	85%
	White	976	55%	1,010	91%	979	57%	1,014	91%	968	57%	971	92%
	Other	141	58%	145	92%	144	52%	151	90%	162	58%	163	92%

Standards of Learning Scores

The Standards of Learning assessments (SOL) are state-mandated tests administered to students in Virginia that measure student mastery of basic academic content at each grade level. The Virginia Department of Education identifies the SOLs as "the minimum grade level and subject matter educational objectives, described as the knowledge and skills necessary for success in school and for preparation for life, that students are expected to meet in Virginia public schools and specified by the Standards of Quality."

There has been an important change in the Mathematics Standards of Learning regarding Algebra readiness. From the 2009 Standards, which governed the testing that took place between 2011 and Fall 2018, "Students who successfully complete the seventh-grade standards should be prepared to study Algebra I in Grade Eight." Beginning in Fall 2018, the new Mathematics Standards state "Algebra readiness describes the mastery of, and the ability to apply, the Mathematics Standards of Learning, including the Mathematical Process Goals for Students, for kindergarten through Grade 8." As a result of this change in the standards and course requirements, the mathematics course sequence pathways and the numbers of students in these classes have been impacted.

The following graphs show overall SOL pass rates for APS students compared to statewide results. Graphs are by grade level. Across grade levels and mathematics content areas, APS students are passing above statewide scores by an average of 10 percent. The only exception is with Algebra ll where APS scores ranged from 2-7 percent above statewide results.

Fluctuations in pass rates for the five year timeline represented in the graphs generally stay within three percentage points. There are a few exceptions where an unexpected rise of five points or a drop of seven does occur. Algebra l and Algebra ll scores are consistently in the low to mid-90 percentage points. Geometry scores are also consistent, but slightly lower, ranging from 86 to 89 percent.

Figure 54: Elementary Mathematics SOL Proficient and Advanced Rates, 2014-15 through 2018-19

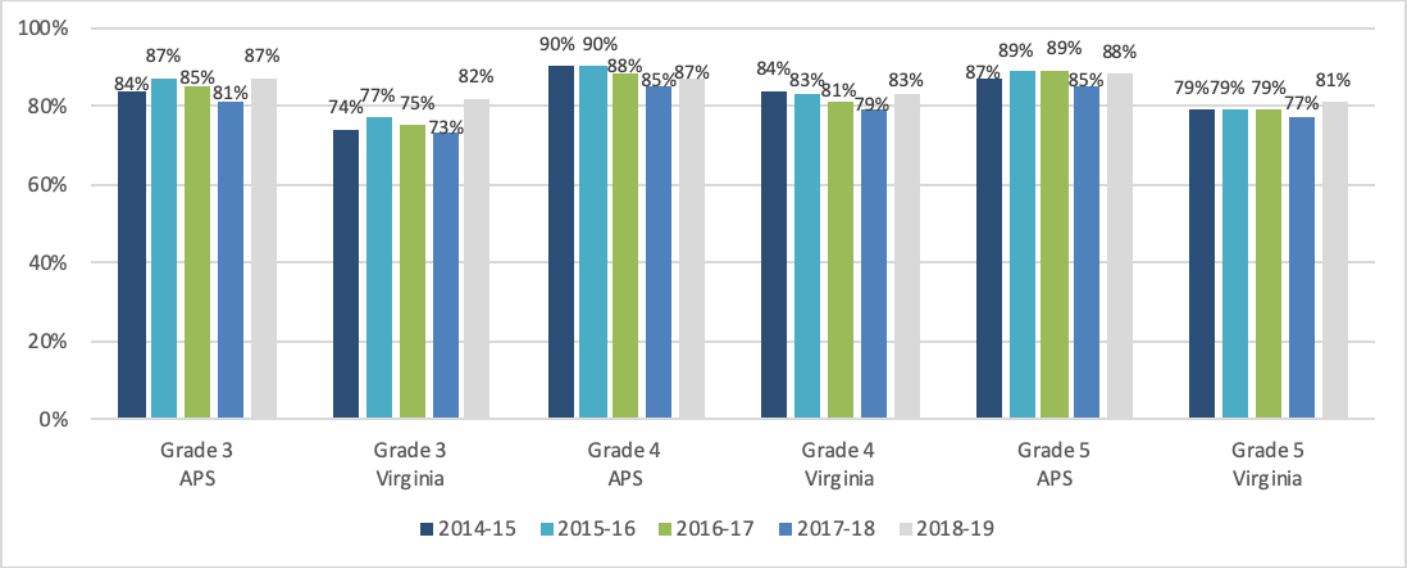


Figure 55: Mathematics 6, 7 and 8 SOL Proficient and Advanced Rates, 2014-15 through 2018-19

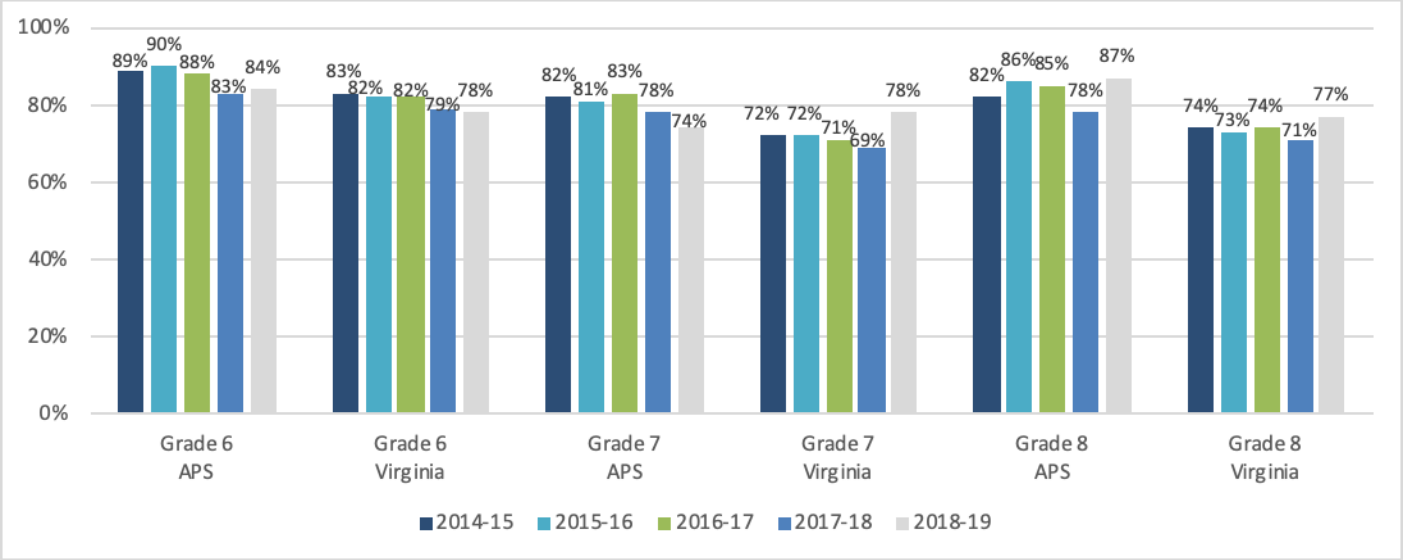
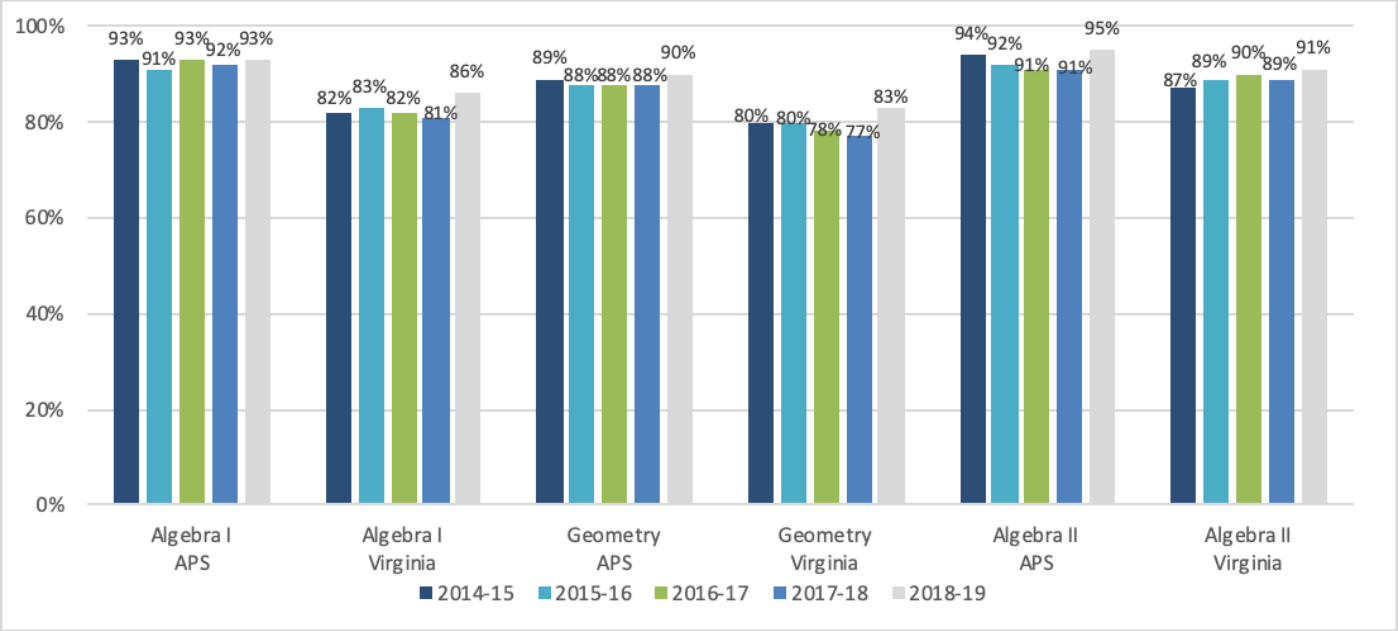


Figure 56: Algebra I, Geometry and Algebra II Mathematics SOL Proficient and Advanced Rates, 2014-15 through 2018-19

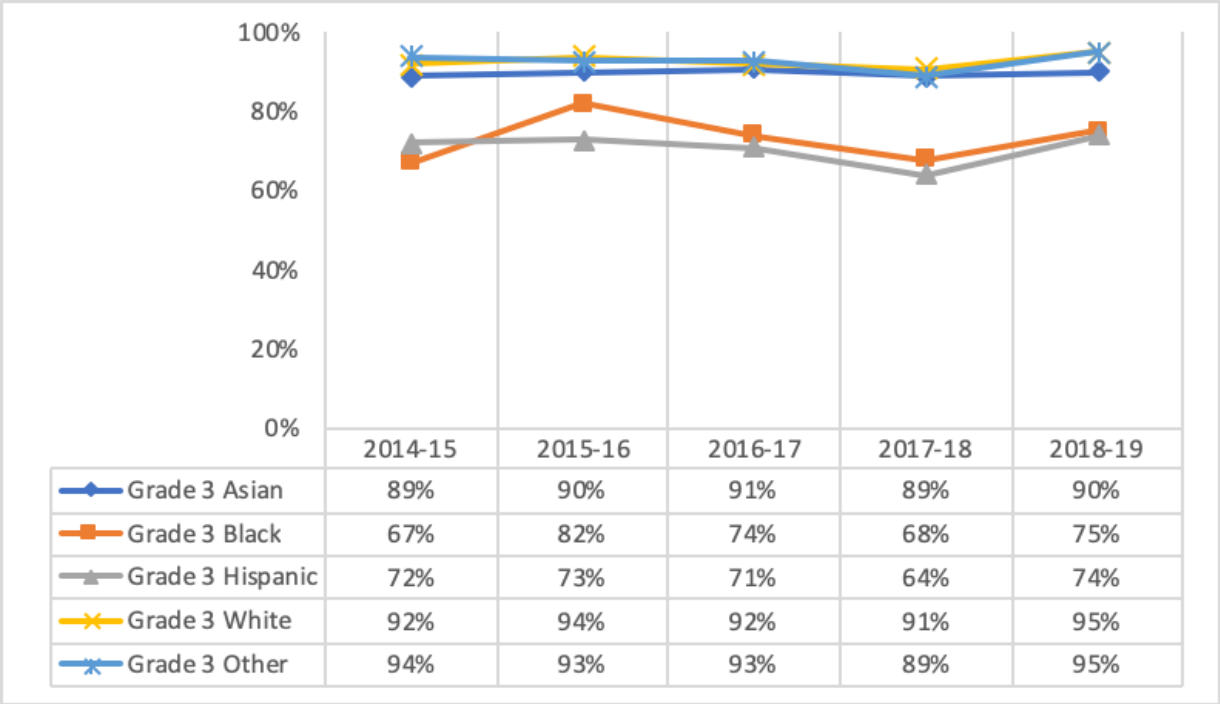


Greater variation in scores is seen when looking at demographic score breakdowns for each grade level. The following table shows the results for the Elementary School Mathematics 3 SOL disaggregated by ethnic background. Only the Mathematics 3 SOL pass rates are shown, as it is representative of all the Elementary School Mathematics SOL results.

- The Elementary School pass rates for each grade show that Asian, White, and Other students have consistent pass rates at or above 90 percent.
- Black students see more fluctuation in their pass rates over time and are generally 15 – 20 percent lower than their Asian, White, and Other classmates.
- Hispanic students are also passing at rates 15 – 20 percent lower than their Asian, White, and Other classmates.

RESULTS BY RACE AND ETHNICITY

Figure 57: Mathematics 3 SOL Proficient and Advanced Pass Rates by Ethnicity, 2014-15 through 2018-19

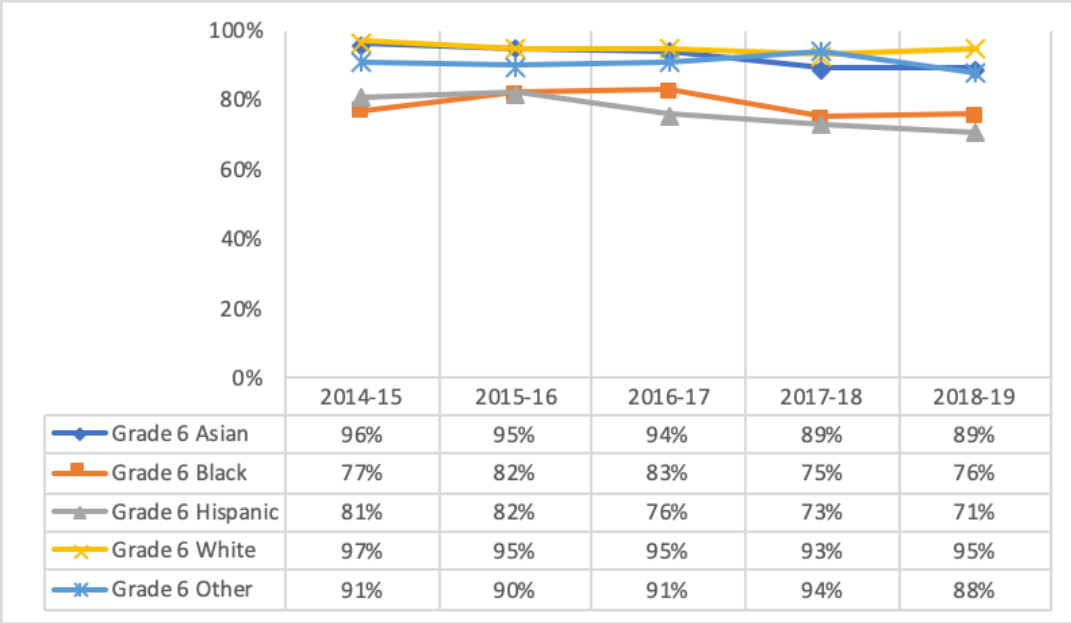


	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 3 Asian	89%	90%	91%	89%	90%
Grade 3 Black	67%	82%	74%	68%	75%
Grade 3 Hispanic	72%	73%	71%	64%	74%
Grade 3 White	92%	94%	92%	91%	95%
Grade 3 Other	94%	93%	93%	89%	95%

The following three tables show Middle School SOL results with scores disaggregated by ethnicity.

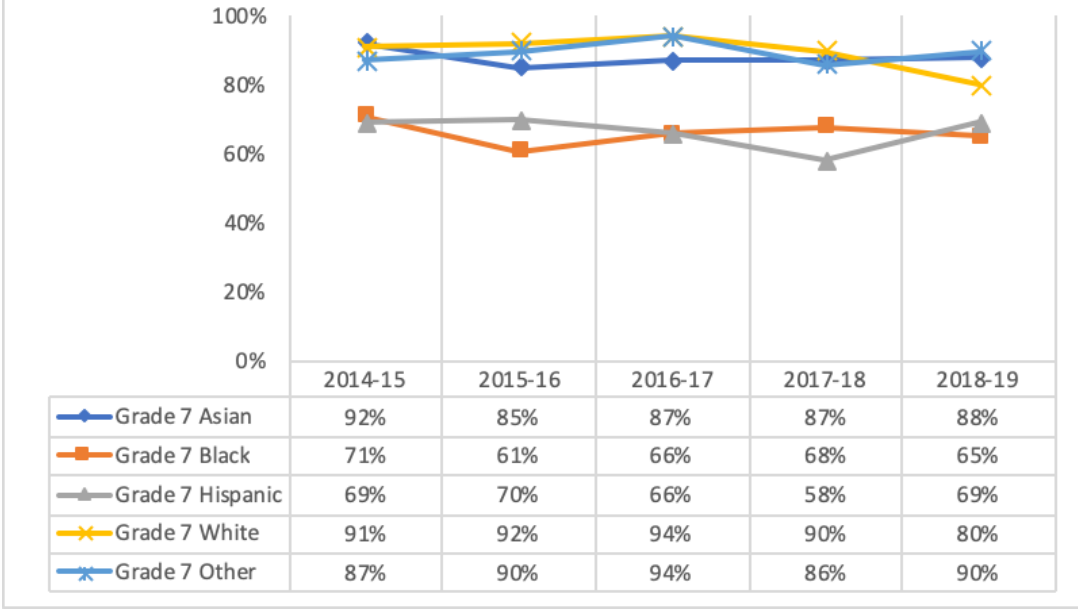
- For each grade level, Asian, White, and Other students generally have scores in the low to mid-90s.
- Black and Hispanic students, however, have average scores ranging 15 – 20 points lower.

Figure 58: Mathematics 6 SOL Proficient and Advanced Rates by Ethnicity, 2014-15 through 2018-19



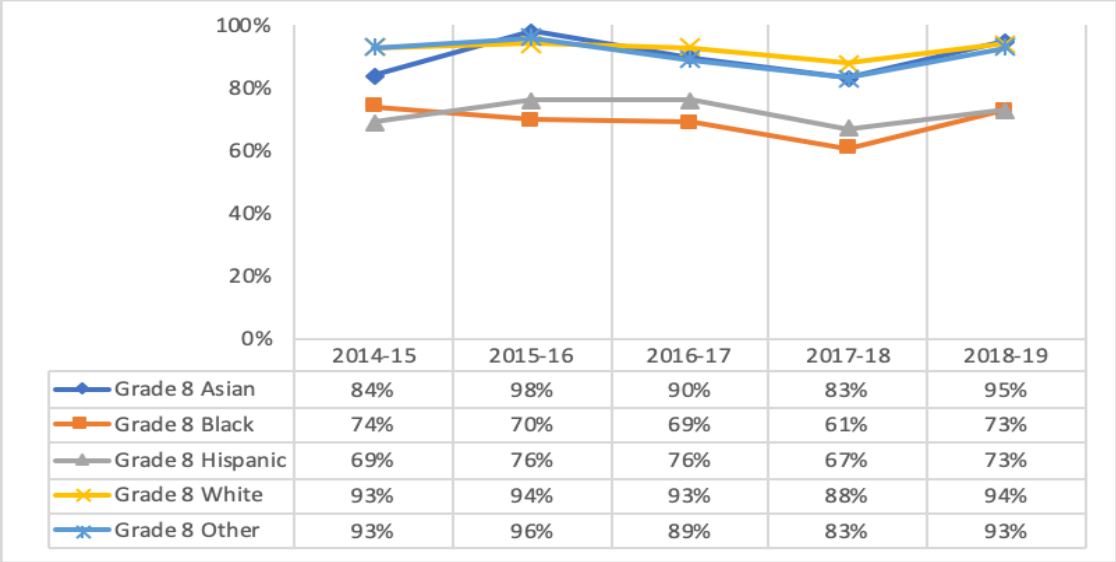
	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 6 Asian	96%	95%	94%	89%	89%
Grade 6 Black	77%	82%	83%	75%	76%
Grade 6 Hispanic	81%	82%	76%	73%	71%
Grade 6 White	97%	95%	95%	93%	95%
Grade 6 Other	91%	90%	91%	94%	88%

Figure 59: Mathematics 7 SOL Proficient and Advanced Rates by Ethnicity, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 7 Asian	92%	85%	87%	87%	88%
Grade 7 Black	71%	61%	66%	68%	65%
Grade 7 Hispanic	69%	70%	66%	58%	69%
Grade 7 White	91%	92%	94%	90%	80%
Grade 7 Other	87%	90%	94%	86%	90%

Figure 60: Mathematics 8 SOL Proficient and Advanced Rates by Ethnicity, 2014-15 through 2018-19

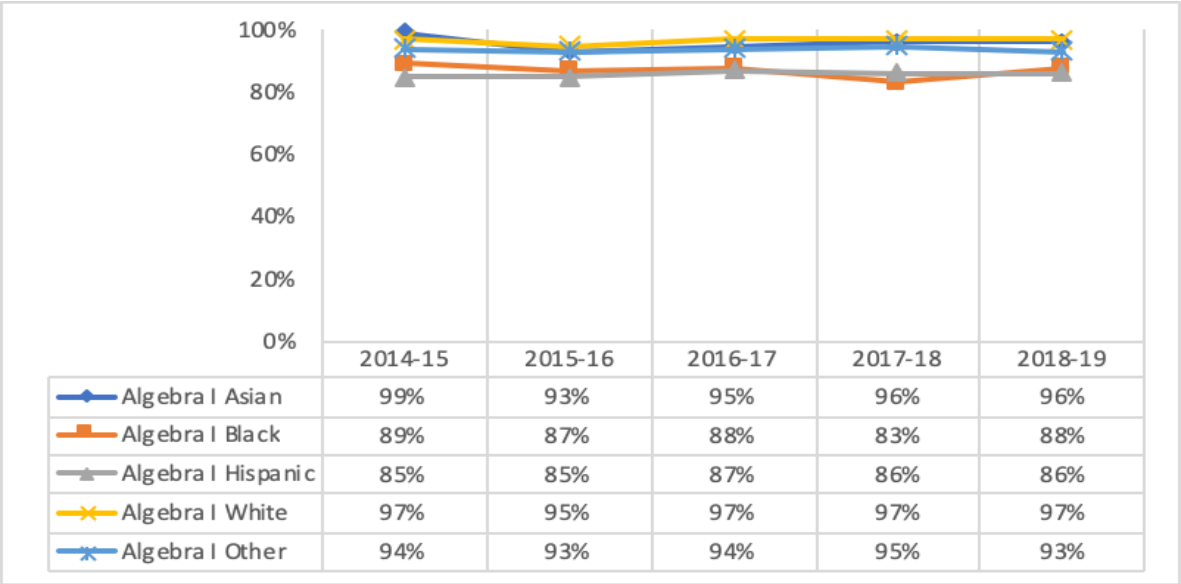


	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 8 Asian	84%	98%	90%	83%	95%
Grade 8 Black	74%	70%	69%	61%	73%
Grade 8 Hispanic	69%	76%	76%	67%	73%
Grade 8 White	93%	94%	93%	88%	94%
Grade 8 Other	93%	96%	89%	83%	93%

The following three tables show the Algebra l, Geometry, and Algebra ll SOL pass rates also broken down by ethnicity. Similar to the Middle School SOL pass rates, Black and Hispanic students are passing at lower rates than their Asian, White, and Other classmates. However, the pass rates demonstrate a lessening of the achievement gap, with Black and Hispanic students passing at 5 – 10 percentage points lower.

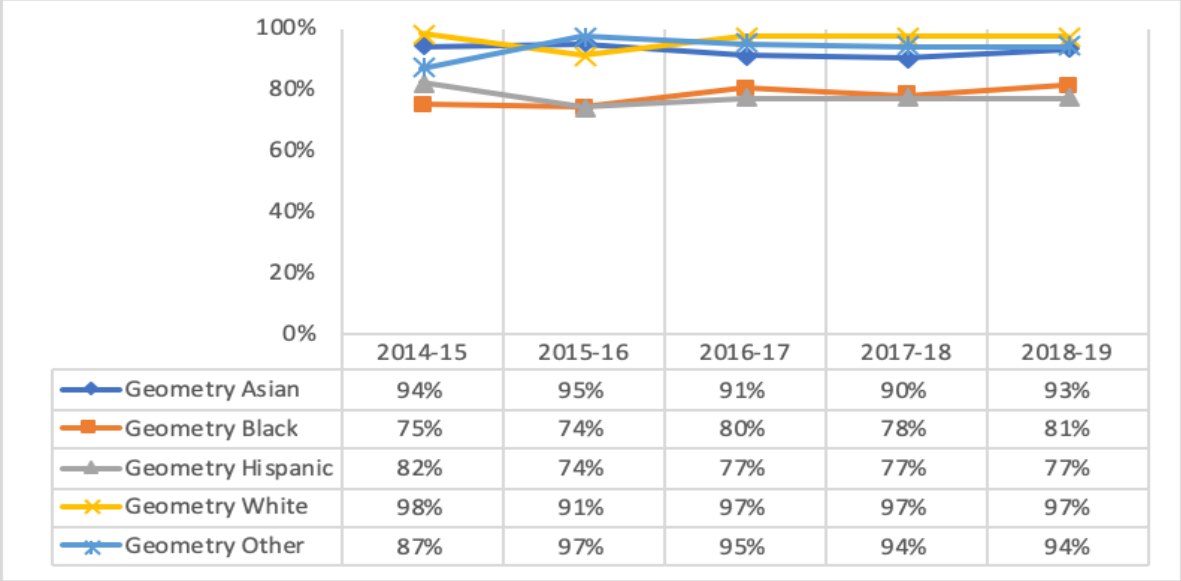
- Black and Hispanic scores are closely aligned. Their pass rates are usually very similar and fall within a few points of each other.
- Last year, Black and Hispanic pass rates in these three courses are some of the highest to date.
- All students have pass rates in the 90s for Algebra ll in 2018-19.

Figure 61: Algebra I SOL Proficient and Advanced Rates by Ethnicity, 2014-15 through 2018-19



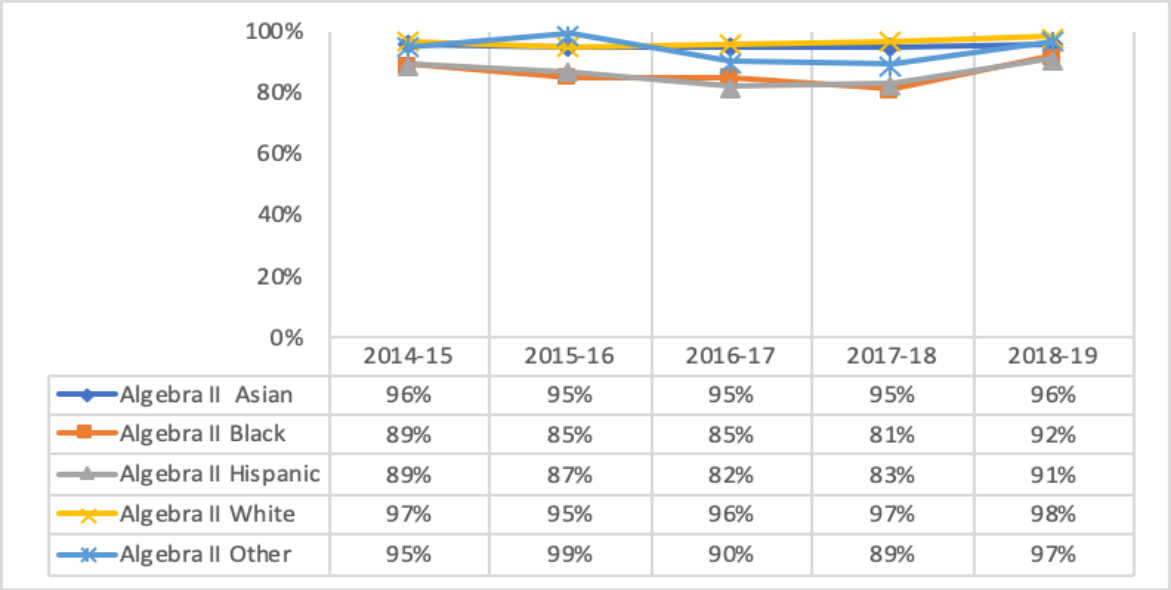
	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra I Asian	99%	93%	95%	96%	96%
Algebra I Black	89%	87%	88%	83%	88%
Algebra I Hispanic	85%	85%	87%	86%	86%
Algebra I White	97%	95%	97%	97%	97%
Algebra I Other	94%	93%	94%	95%	93%

Figure 62: Geometry SOL Proficient and Advanced Rates by Ethnicity, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Geometry Asian	94%	95%	91%	90%	93%
Geometry Black	75%	74%	80%	78%	81%
Geometry Hispanic	82%	74%	77%	77%	77%
Geometry White	98%	91%	97%	97%	97%
Geometry Other	87%	97%	95%	94%	94%

Figure 63: Algebra ll SOL Proficient and Advanced Rates by Ethnicity, 2014-15 through 2018-19

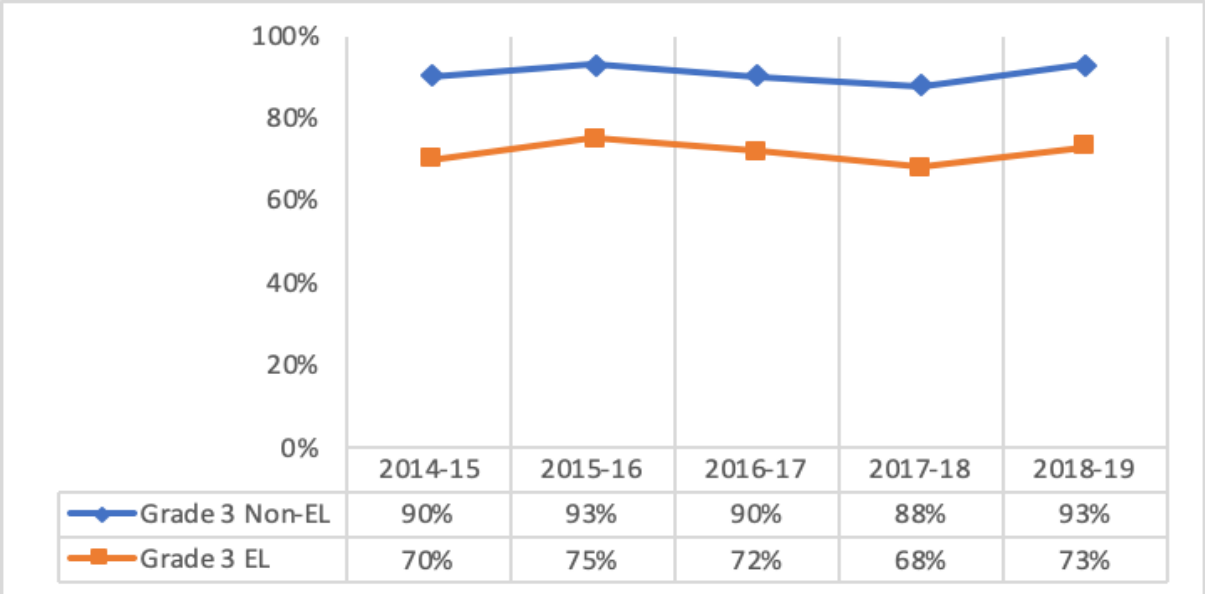


	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra II Asian	96%	95%	95%	95%	96%
Algebra II Black	89%	85%	85%	81%	92%
Algebra II Hispanic	89%	87%	82%	83%	91%
Algebra II White	97%	95%	96%	97%	98%
Algebra II Other	95%	99%	90%	89%	97%

RESULTS BY ENGLISH LEARNER STATUS

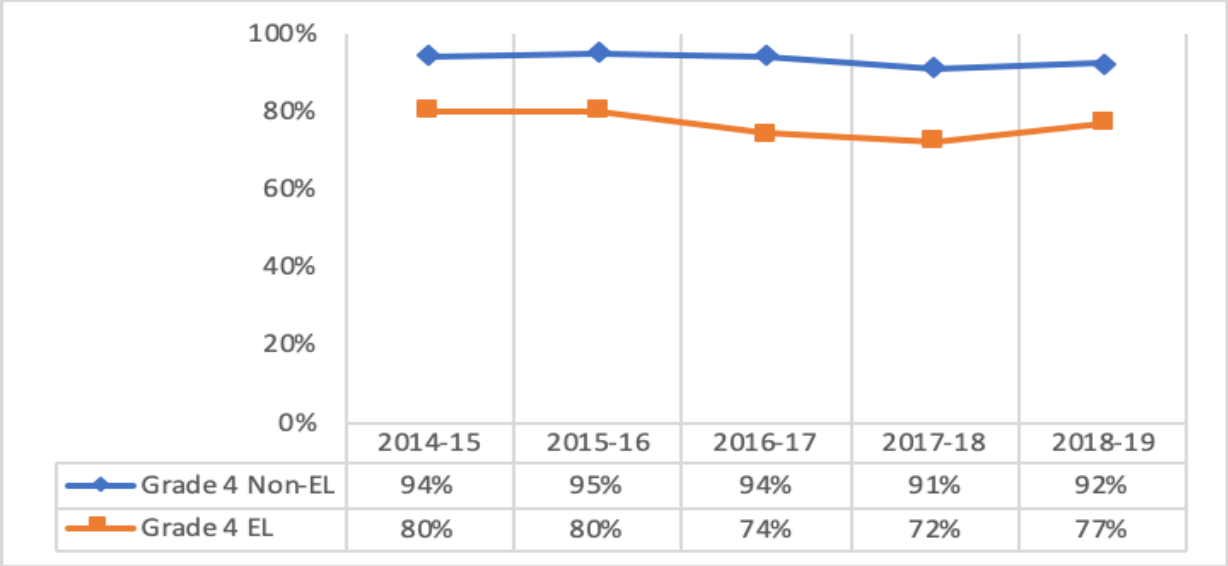
The following graphs show Elementary Mathematics SOL results disaggregated by EL status. In general, EL students are passing at rates 15 – 20 percent lower than their Non-EL peers. There is similarity in the trend line trajectory between the EL and Non-EL students; however, the EL trend line is 15 – 20 points lower.

Figure 64: Grade 3 Mathematics SOL Proficient and Advanced Pass Rates by EL status, 2014-15 through 2018-19



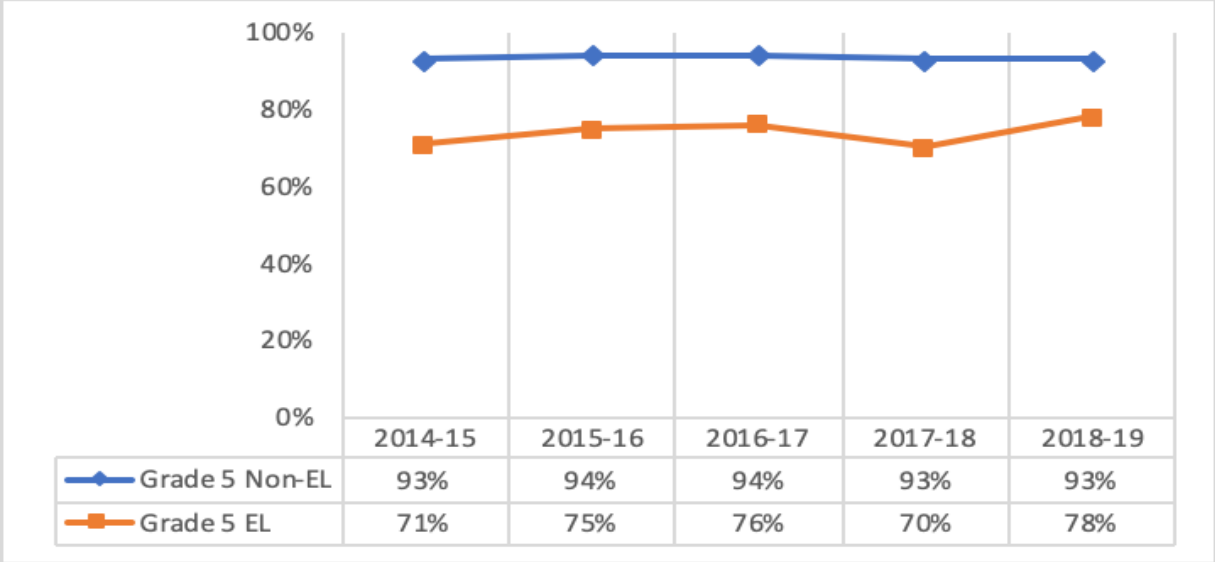
	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 3 Non-EL	90%	93%	90%	88%	93%
Grade 3 EL	70%	75%	72%	68%	73%

Figure 65: Grade 4 Mathematics SOL Proficient and Advanced Pass Rates by EL Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 4 Non-EL	94%	95%	94%	91%	92%
Grade 4 EL	80%	80%	74%	72%	77%

Figure 66: Grade 5 Mathematics SOL Proficient and Advanced Rates by EL Status, 2014-15 through 2018-19



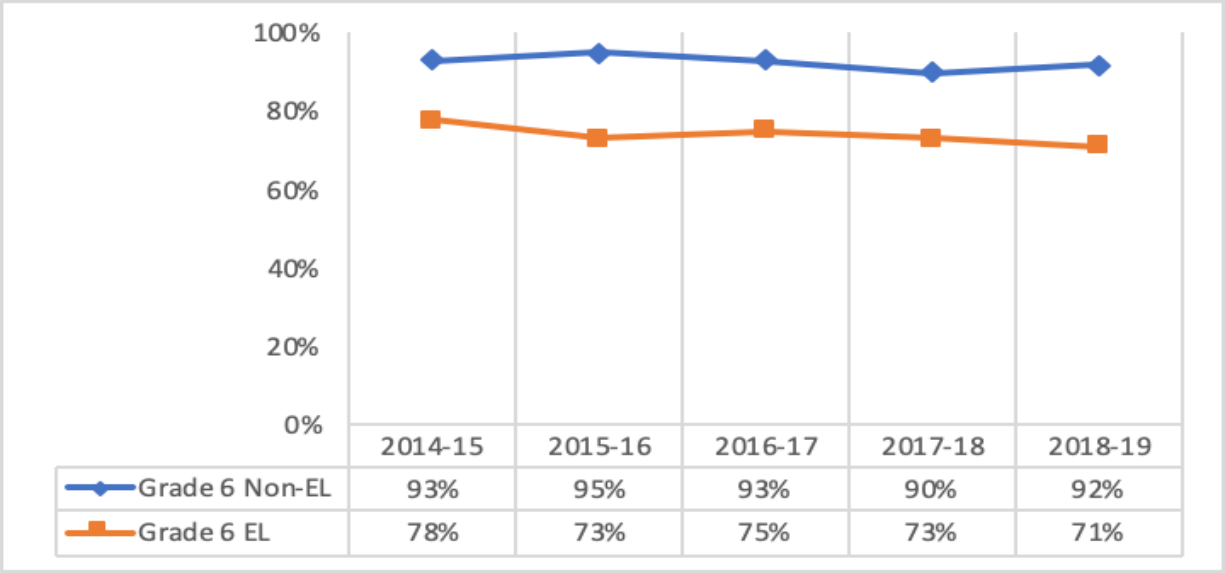
	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 5 Non-EL	93%	94%	94%	93%	93%
Grade 5 EL	71%	75%	76%	70%	78%

Figures 67 through 70, show the Middle School SOL results disaggregated by EL status.

- In Grade 6 Mathematics, EL students are passing at 15 – 20 percent lower than Non-EL students.
- In Grade 7 Mathematics, EL students have seen the most fluctuation in scores from passing rates as much as 35 percent lower than Non-EL students to a much closer 11 percent differential on the 2018-19 test.

- Grade 8 Mathematics pass rates for EL students have been increasing over the past five years, but are still averaging about 20 percent lower than Non-EL students. However, when looking at the WIDA Proficiency Level, as English proficiency increases, EL students are passing at rates commensurate with Non-EL students.

Figure 67: Grade 6 Mathematics SOL Proficient and Advanced Rates by EL Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 6 Non-EL	93%	95%	93%	90%	92%
Grade 6 EL	78%	73%	75%	73%	71%

Figure 68: Grade 6 Mathematics SOL EL Student Pass Rate by WIDA Proficiency Level, 2017-18 - 2018-19

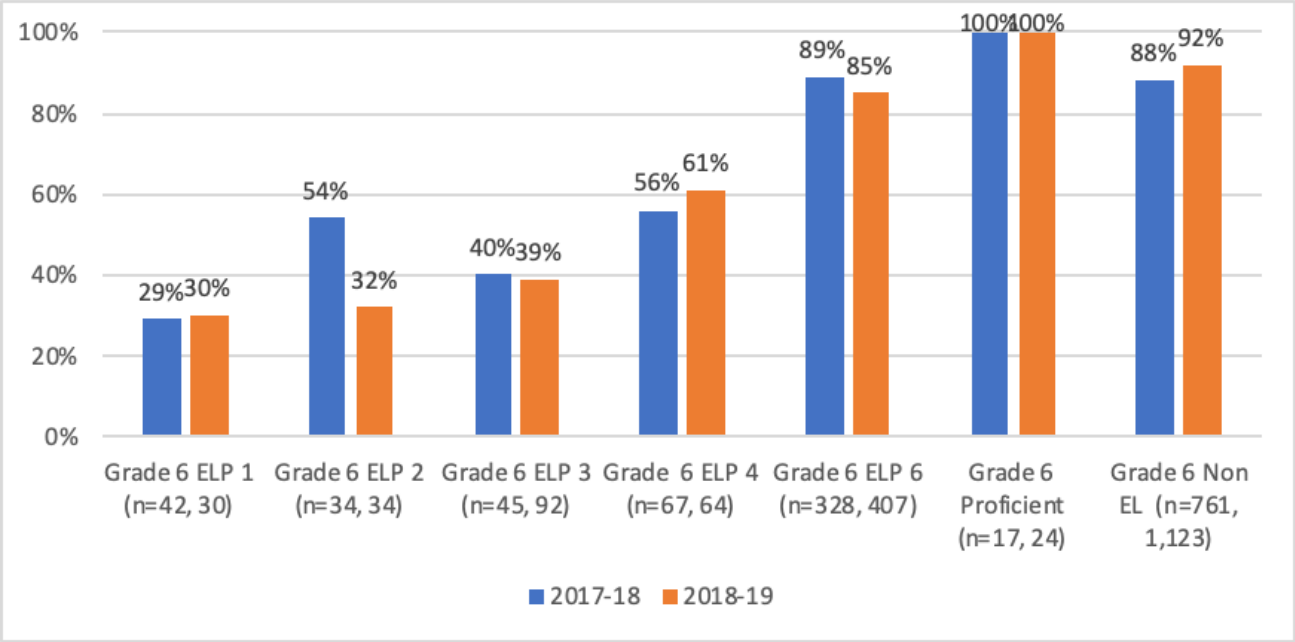
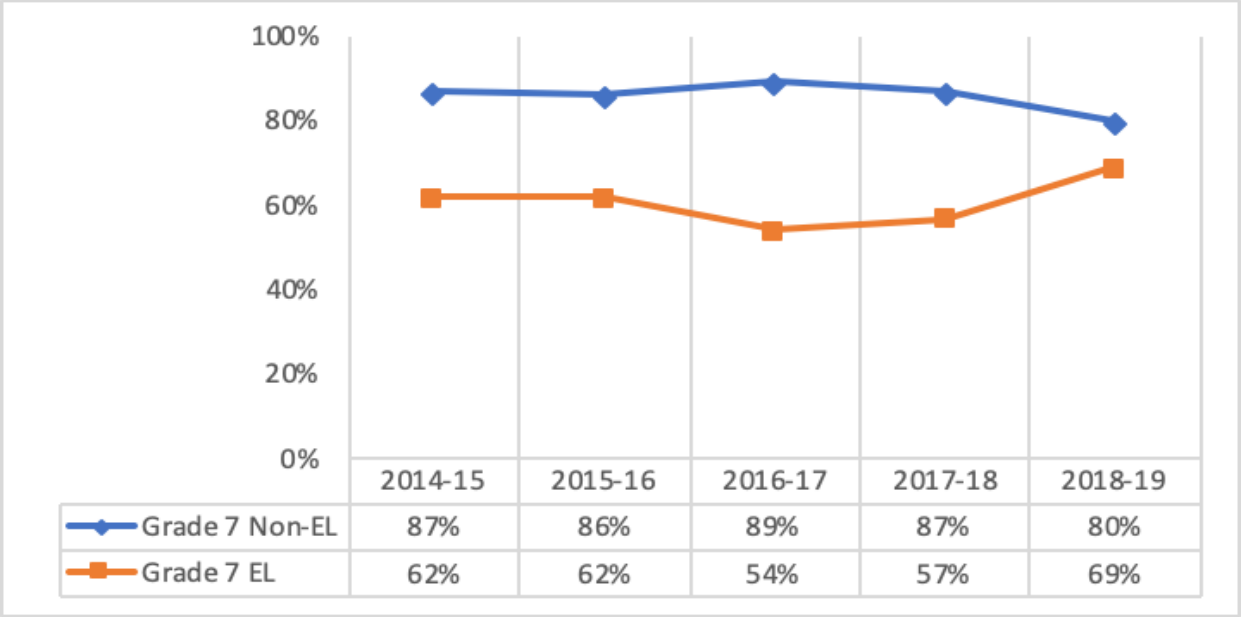
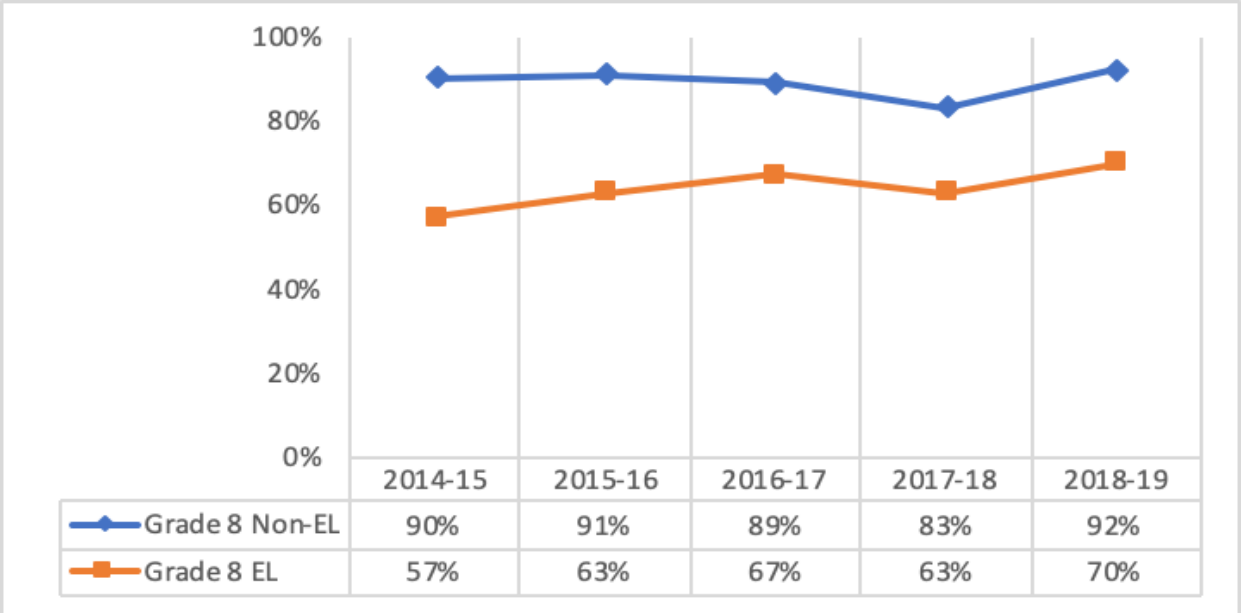


Figure 69: Grade 7 Mathematics SOL Proficient and Advanced Pass Rate by EL Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 7 Non-EL	87%	86%	89%	87%	80%
Grade 7 EL	62%	62%	54%	57%	69%

Figure 70: Mathematics 8 SOL Proficient and Advanced Pass Rate by EL Status, 2014-15 through 2018-19

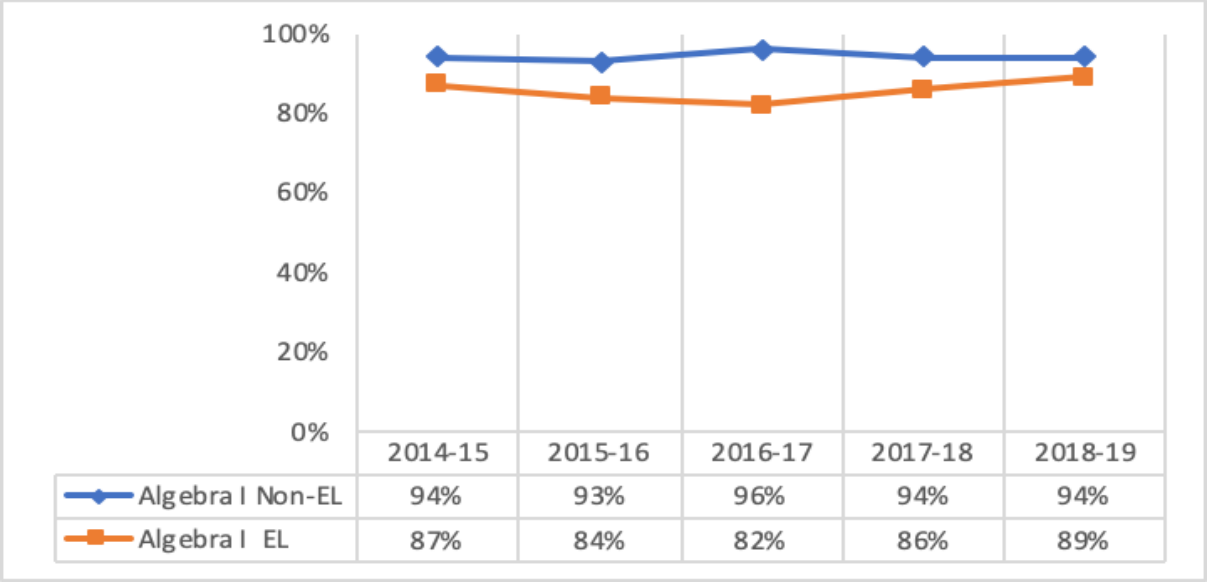


	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 8 Non-EL	90%	91%	89%	83%	92%
Grade 8 EL	57%	63%	67%	63%	70%

Figures 71 through 76 show pass rate results from the Algebra I, Geometry, and Algebra II SOLs.

- EL students in the Algebra I and Algebra II courses are passing at levels much closer to their Non-EL classmates with rates at 89 and 86 percent respectively.
- Pass rates in Geometry for EL students are much lower with pass rates at or more than 20 percent lower than Non-EL students. There is a significant difference in pass rates when looking at WIDA Proficiency Levels. Students at higher WIDA levels have greater pass rates.

Figure 71: Algebra I Mathematics SOL Proficient and Advanced Rates by EL status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra I Non-EL	94%	93%	96%	94%	94%
Algebra I EL	87%	84%	82%	86%	89%

Figure 72: Algebra I EL Pass Rate by WIDA Proficiency Level, 2017-18 - 2018-19

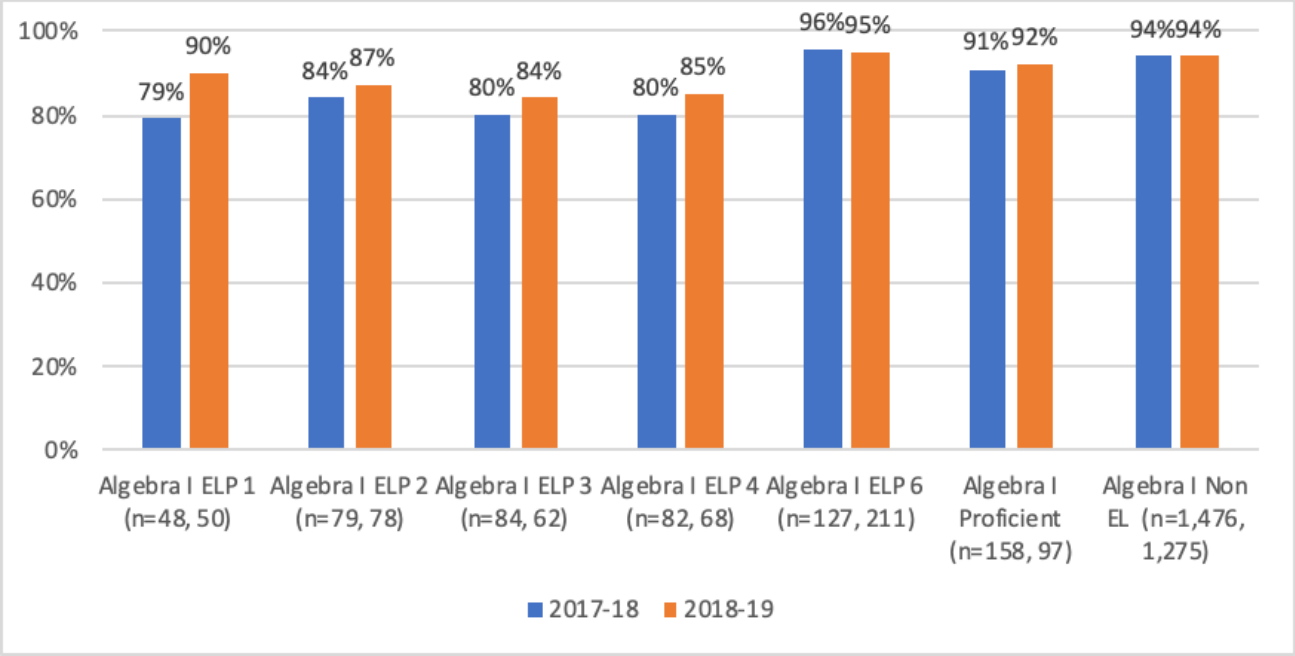
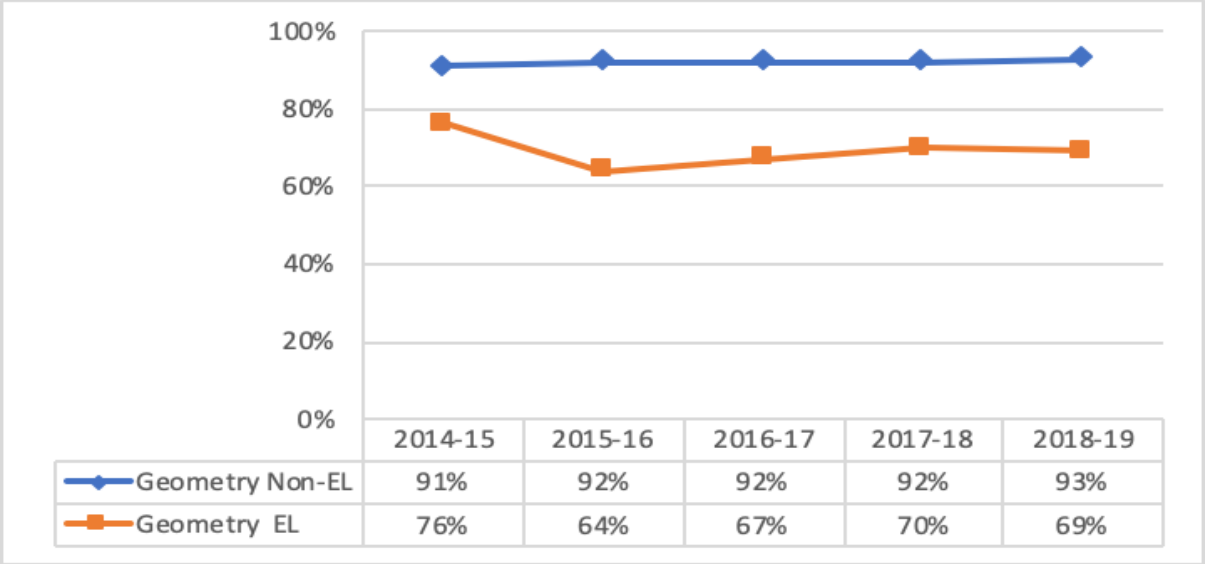


Figure 73: Geometry SOL Proficient and Advanced Pass Rates by EL Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Geometry Non-EL	91%	92%	92%	92%	93%
Geometry EL	76%	64%	67%	70%	69%

Figure 74: Geometry SOL EL Pass Rate by WIDA Proficiency Level, 2017-18 through 2018-19

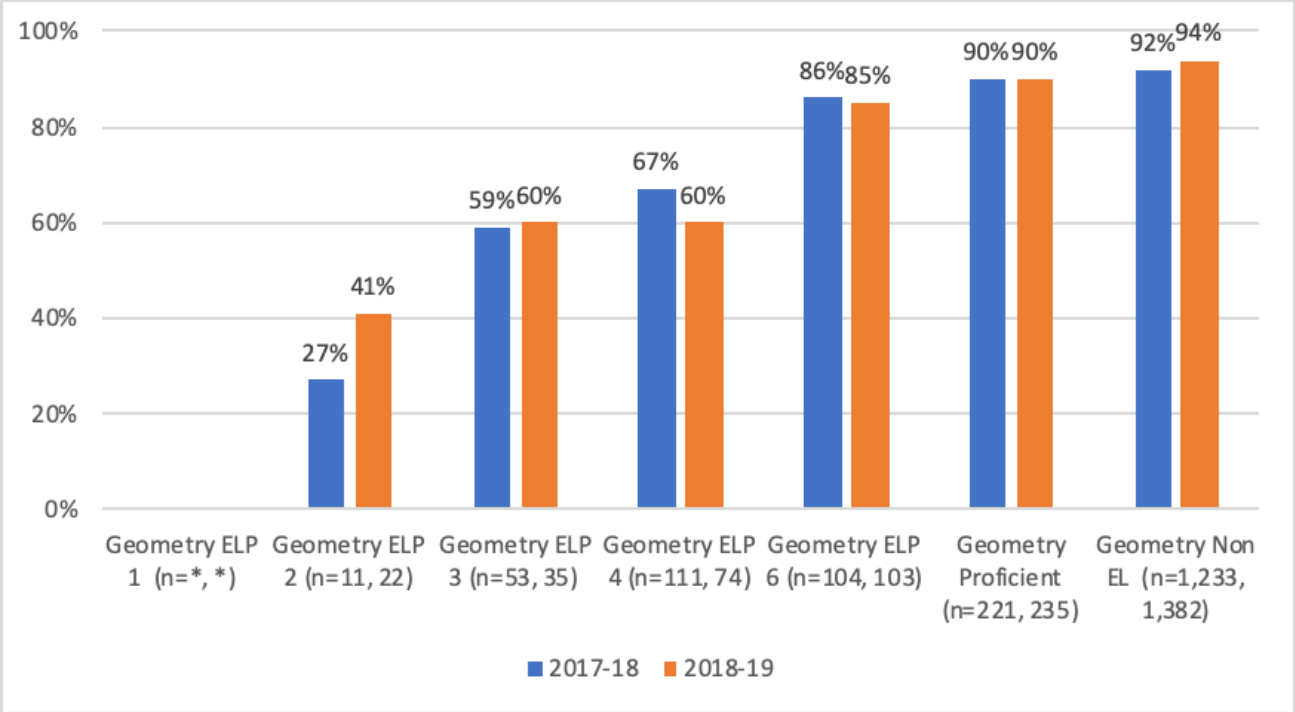
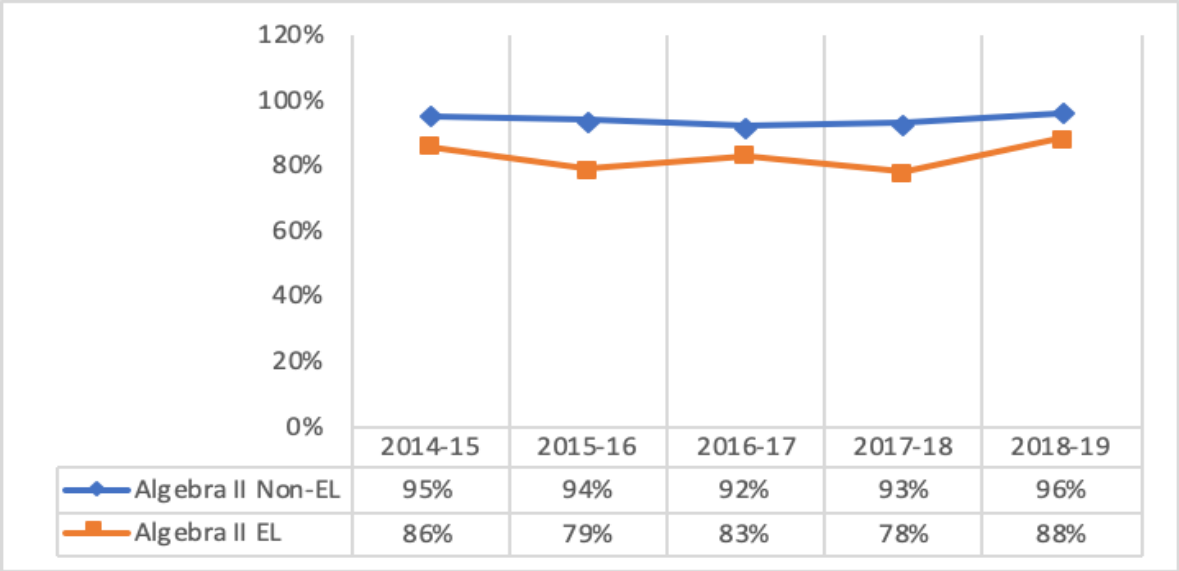
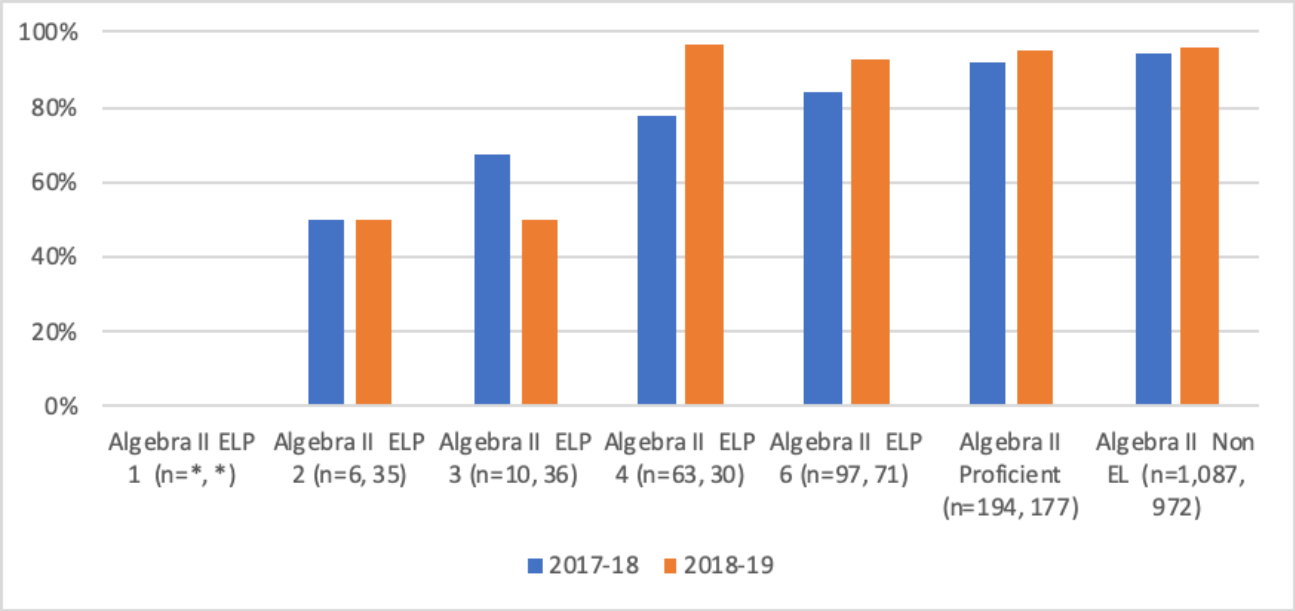


Figure 75: Algebra II SOL Proficient and Advanced Pass Rates by EL Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra II Non-EL	95%	94%	92%	93%	96%
Algebra II EL	86%	79%	83%	78%	88%

Figure 76: Algebra II SOL EL Pass Rate by WIDA Proficiency Level, 2017-18 through 2018-19

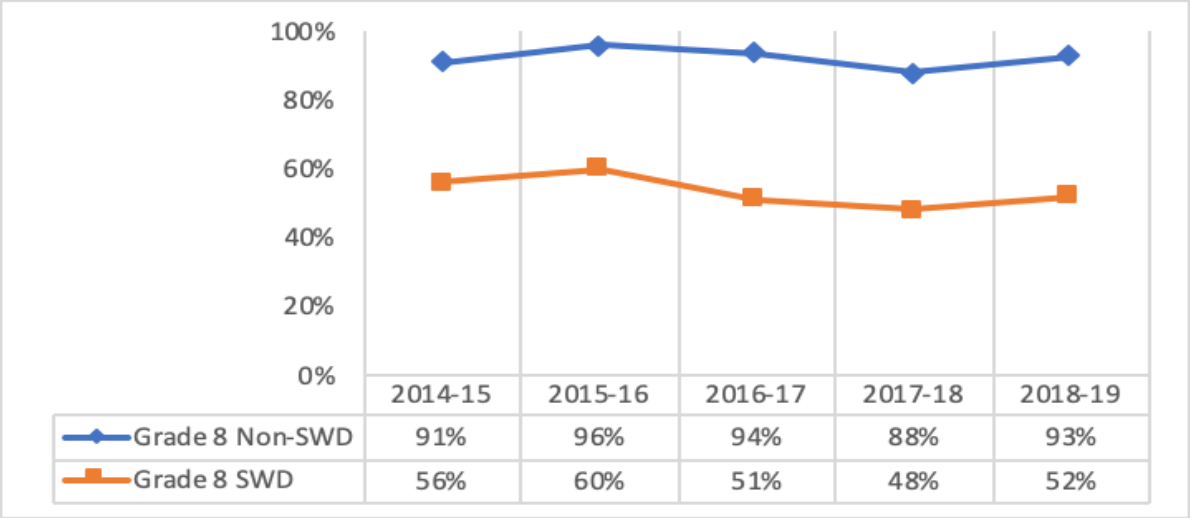


RESULTS BY STUDENTS WITH DISABILITIES STATUS

The following figures focus on SOL results that look specifically at students who have an SWD designation. The pass rate gap narrows at for the Algebra I, Geometry, and Algebra II tests.

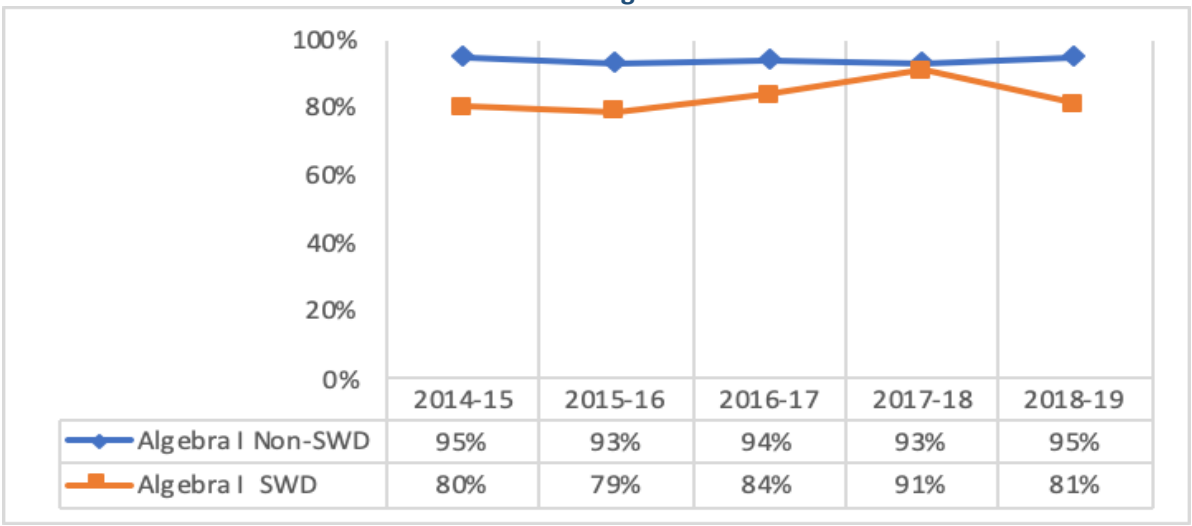
- In Mathematics 8, SWD students score, on average 40 percent lower than their Non-SWD peers.
- Algebra I SOL results show a comparatively much narrower gap scoring 10 – 15 percent below their Non-SWD peers. In 2017-18, SWD students were performing almost even with Non-SWD students.
- In Geometry, SWD students are passing at 15 – 20 percent below Non-SWD students.
- In Algebra II, SWD students are passing at 10 – 15 percent below Non-SWD students.

Figure 77: Mathematics 8 SOL Proficient and Advanced Pass Rates by SWD Status, 2014-15 through 2018-19



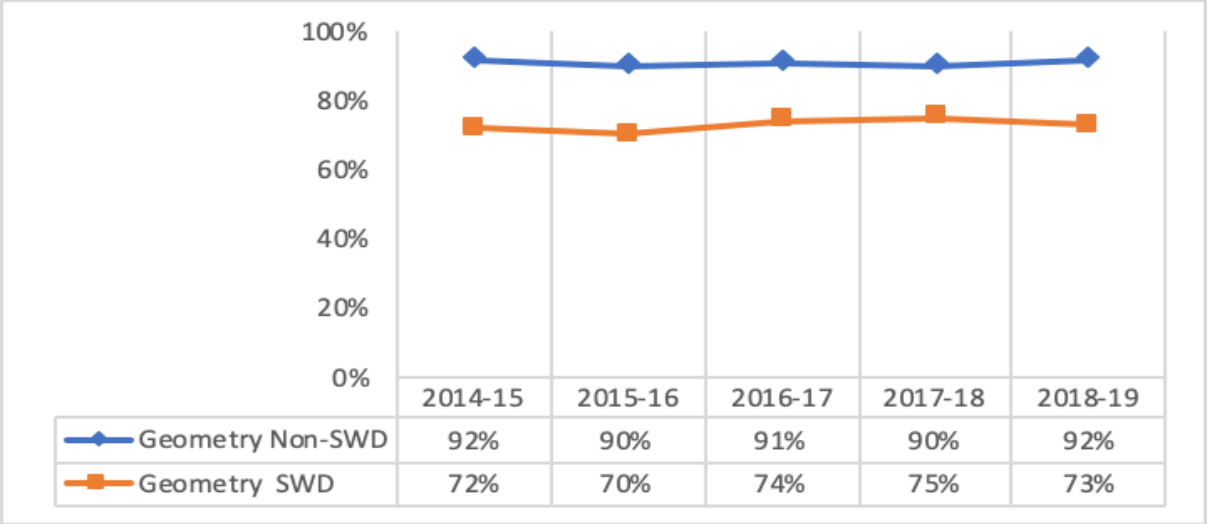
	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 8 Non-SWD	91%	96%	94%	88%	93%
Grade 8 SWD	56%	60%	51%	48%	52%

Figure 78: Algebra I SOL Proficient and Advanced Pass Rates by SWD Status, 2014-15 through 2018-19



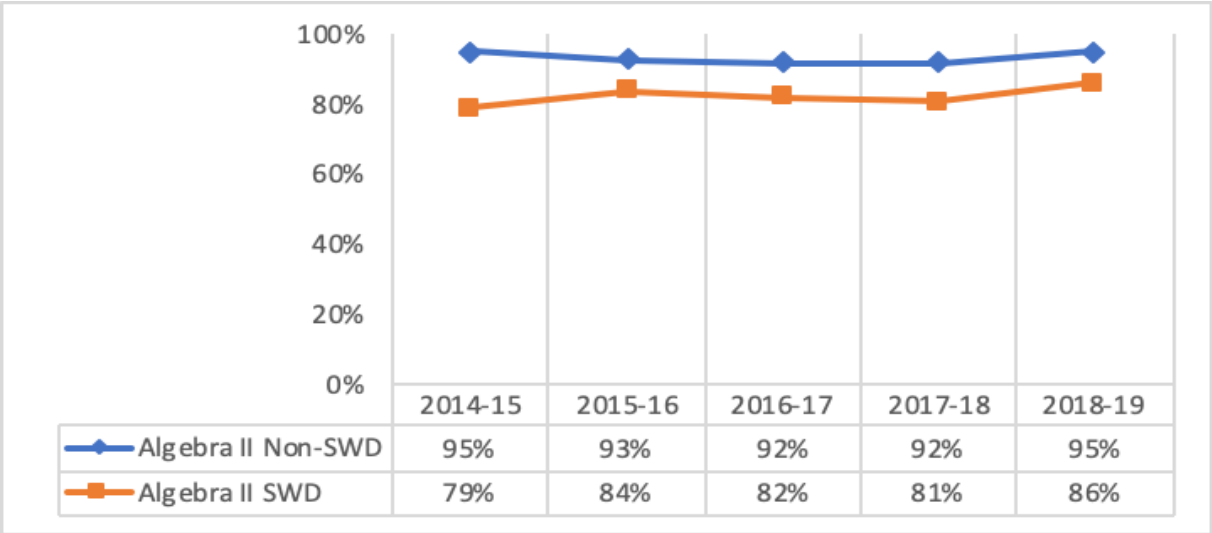
	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra I Non-SWD	95%	93%	94%	93%	95%
Algebra I SWD	80%	79%	84%	91%	81%

Figure 79: Geometry SOL Proficient and Advanced Pass Rates by SWD Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Geometry Non-SWD	92%	90%	91%	90%	92%
Geometry SWD	72%	70%	74%	75%	73%

Figure 80: Algebra II SOL Proficient and Advanced Pass Rates by SWD Status, 2014-15 through 2018-19



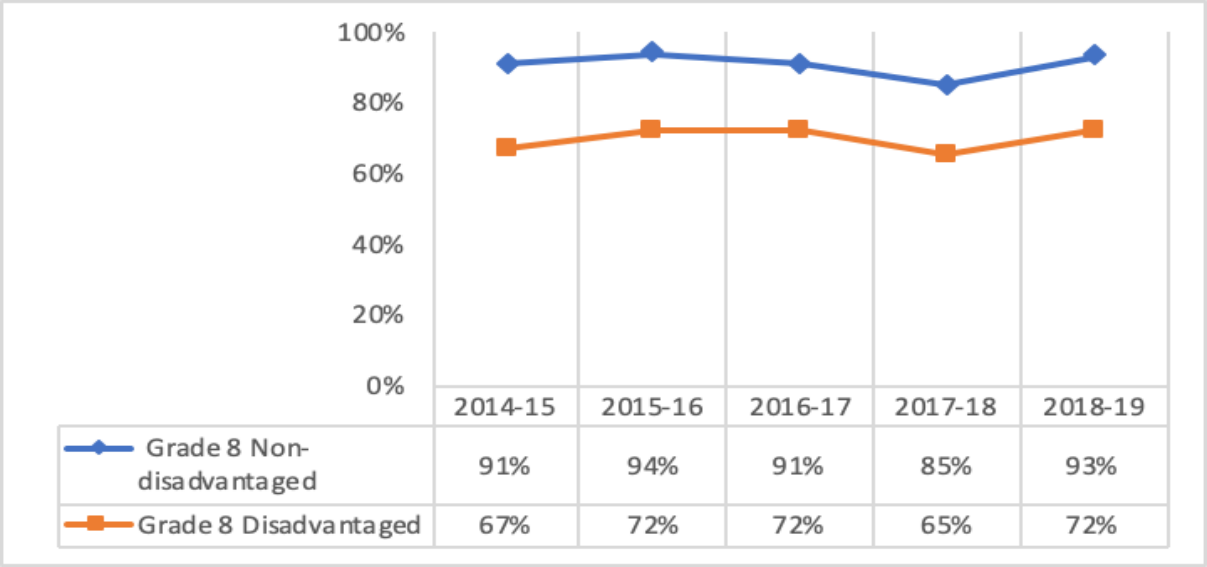
	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra II Non-SWD	95%	93%	92%	92%	95%
Algebra II SWD	79%	84%	82%	81%	86%

The following graphs focus on SOL results that look specifically at students with a Economically Disadvantaged Student Status.

- Over the past five years, Disadvantaged Students have been passing Mathematics 8 below Non-Disadvantaged students by 20 percent. Their pass rate trajectory mirrors the Non-Disadvantaged trajectory but the 20 percent gap remains consistent.
- In Algebra I, Disadvantaged Student pass rates are much closer to Non-Disadvantaged pass rates, falling between 5 to 12 percent below Non-Disadvantaged Students. The 2018-19 scores saw the highest pass rate for Disadvantaged Students, at 90 percent.

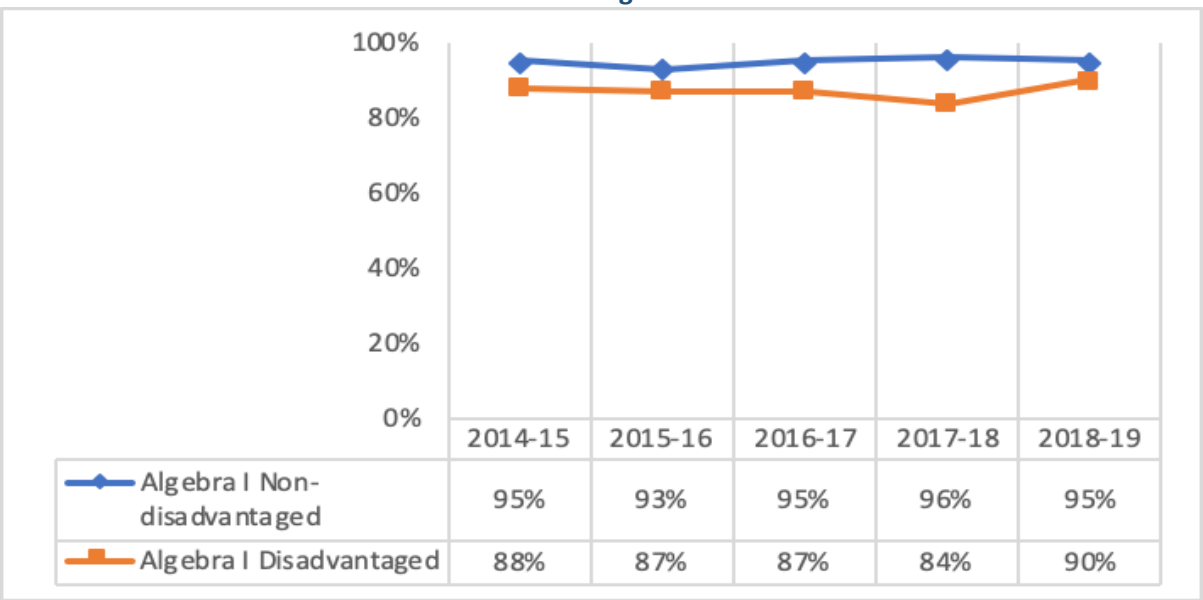
- In Geometry, Disadvantaged Students are passing at about 20 percent below Non-Disadvantaged Students.
- In Algebra II, the achievement gap narrows somewhat with Disadvantaged Students passing from about 5 – 10 points below their Non-Disadvantaged peers.

Figure 81: Mathematics 8 SOL Proficient and Advanced Pass Rates by Disadvantaged Status, 2014-15 through 2018-19



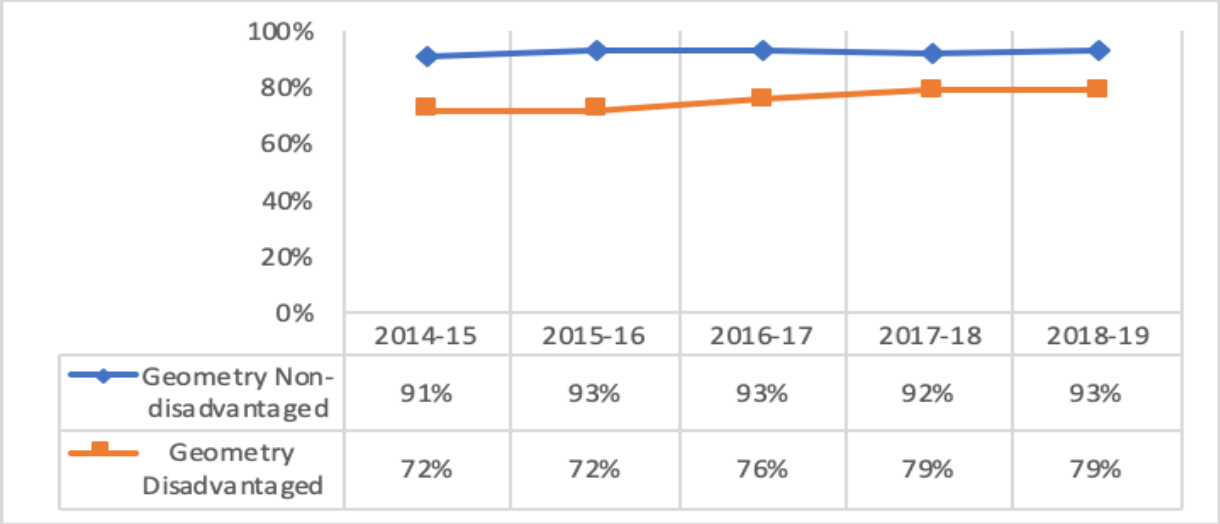
	2014-15	2015-16	2016-17	2017-18	2018-19
Grade 8 Non-disadvantaged	91%	94%	91%	85%	93%
Grade 8 Disadvantaged	67%	72%	72%	65%	72%

Figure 82: Algebra I SOL Proficient and Advanced Pass Rates by Disadvantaged Status, 2014-15 through 2018-19



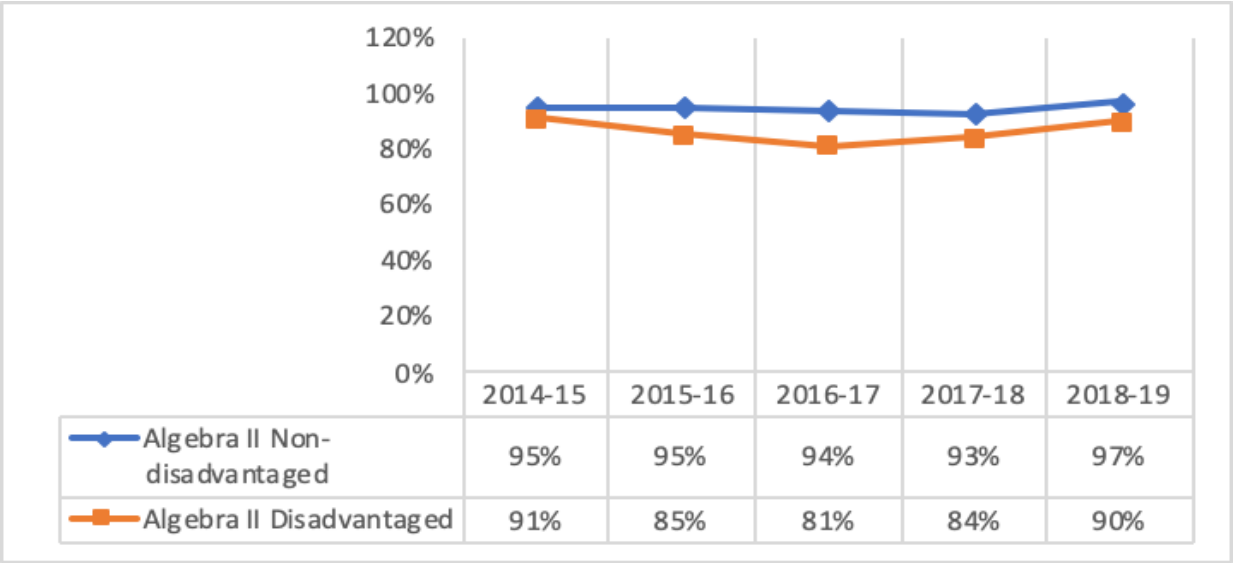
	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra I Non-disadvantaged	95%	93%	95%	96%	95%
Algebra I Disadvantaged	88%	87%	87%	84%	90%

Figure 83: Geometry SOL Proficient and Advanced Pass Rates by Disadvantaged Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Geometry Non-disadvantaged	91%	93%	93%	92%	93%
Geometry Disadvantaged	72%	72%	76%	79%	79%

Figure 84: Algebra II SOL Proficient and Advanced Pass Rates by Disadvantaged Status, 2014-15 through 2018-19



	2014-15	2015-16	2016-17	2017-18	2018-19
Algebra II Non-disadvantaged	95%	95%	94%	93%	97%
Algebra II Disadvantaged	91%	85%	81%	84%	90%

MIDDLE SCHOOL ALGEBRA I PROGRAM

End of Course SOL results clearly show that middle school students taking Algebra I and higher-level mathematics courses are demonstrating that they are capable of studying the mathematics content and classwork, leading to passing scores on the Standards of Learning assessment. Middle school students taking the end of course mathematics assessments outperform the high school student test-takers on all three tests.

Table 38: End of Course Mathematics SOL Results by School Level, 2013-14 through 2017-18

Level	Year	Algebra I SOL		Geometry SOL		Algebra II SOL	
		# tested	% passed	# tested	% passed	# tested	% passed
Middle School	2013-14	1,178	**96%**	175	**100%**	4	*
	2014-15	1,246	**96%**	265	**100%**	9	100%
	2015-16	1,324	**95%**	271	**100%**	6	100%
	2016-17	1,344	**98%**	293	**100%**	1	*
	2017-18	1,530	**97%**	314	**99%**	**10**	100%
High School	2013-14	746	**83%**	1,339	**84%**	1,248	89%
	2014-15	654	**86%**	1,449	**87%**	1,286	94%
	2015-16	738	**83%**	1,380	**85%**	1,428	**92%**
	2016-17	667	**82%**	1,485	**86%**	1,426	91%
	2017-18	600	**80%**	1,419	**86%**	**1,456**	91%

*Results for sample sizes less than 5 are not reported

Hanover Research Council

In addition to the HRC study findings pertaining to Student Access, additional analysis provided information about how important success in the middle school mathematics sequence is for eventual success in high school advanced classes.

- Early participation in advanced classes in middle school is strongly associated with eventual progression to advanced courses in high school and on performance. Students who take Algebra I, Intensified in Grade 7 are more likely to reach Algebra II, Intensified, AP Calculus BC, and AP Calculus AB and achieve better results on respective AP exams.
- Students who enter Grade 6 as Monitored EL students tend to reach credit-bearing mathematics courses at APS in later grade levels as compared to those who enter as HILT or HILTEX students. At the same time, more Monitored students pass these classes at their first attempt.

- Around 87-88 percent of Special Education students reach credit-bearing classes by Grade 9 and 62 - 69 percent of these students pass their first credit-bearing class on their first attempt.

Figure 85: Hanover Report: Percentage of Students taking Algebra II Intensified by Middle School

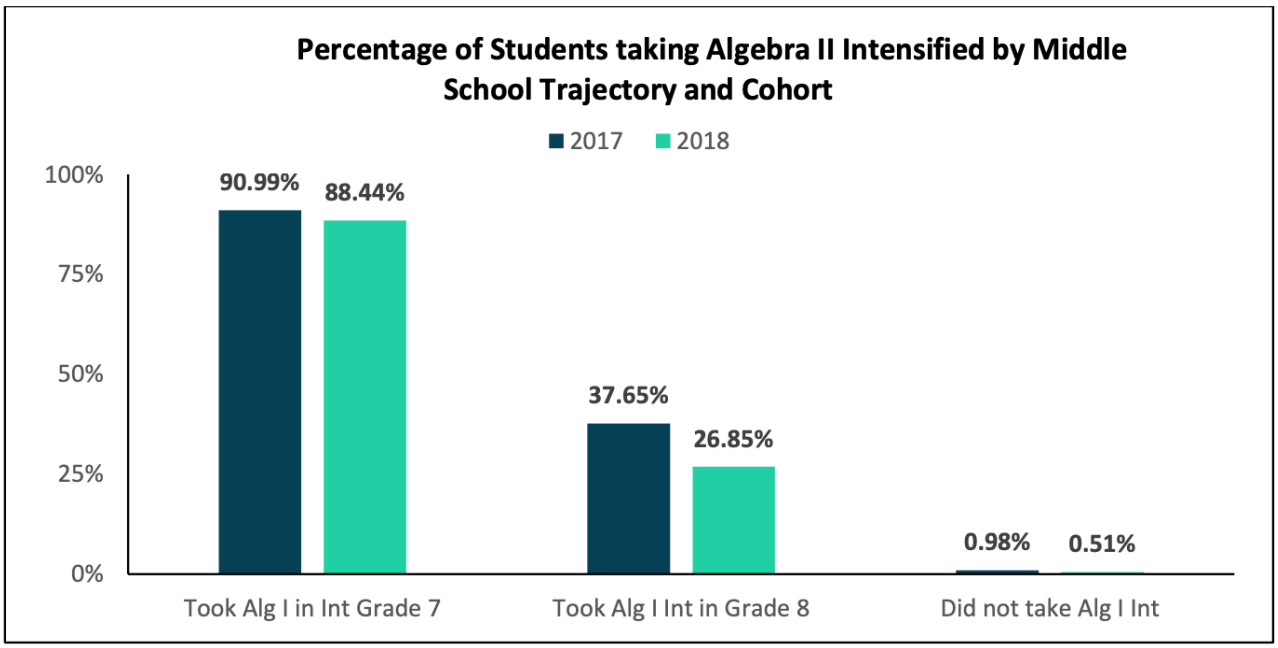


Figure 86: Hanover Report: Percentage of Students taking AP Calculus BC by Middle School

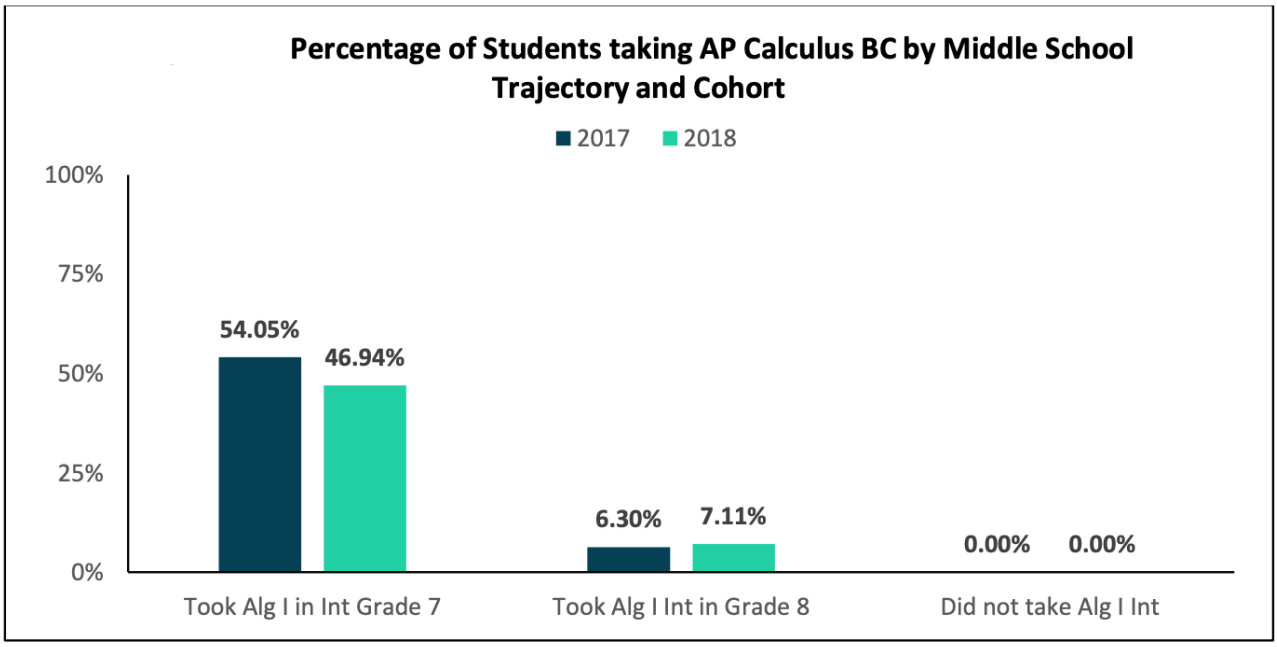


Figure 87: Hanover Report: Performance on AP Calculus BC Test by Middle School

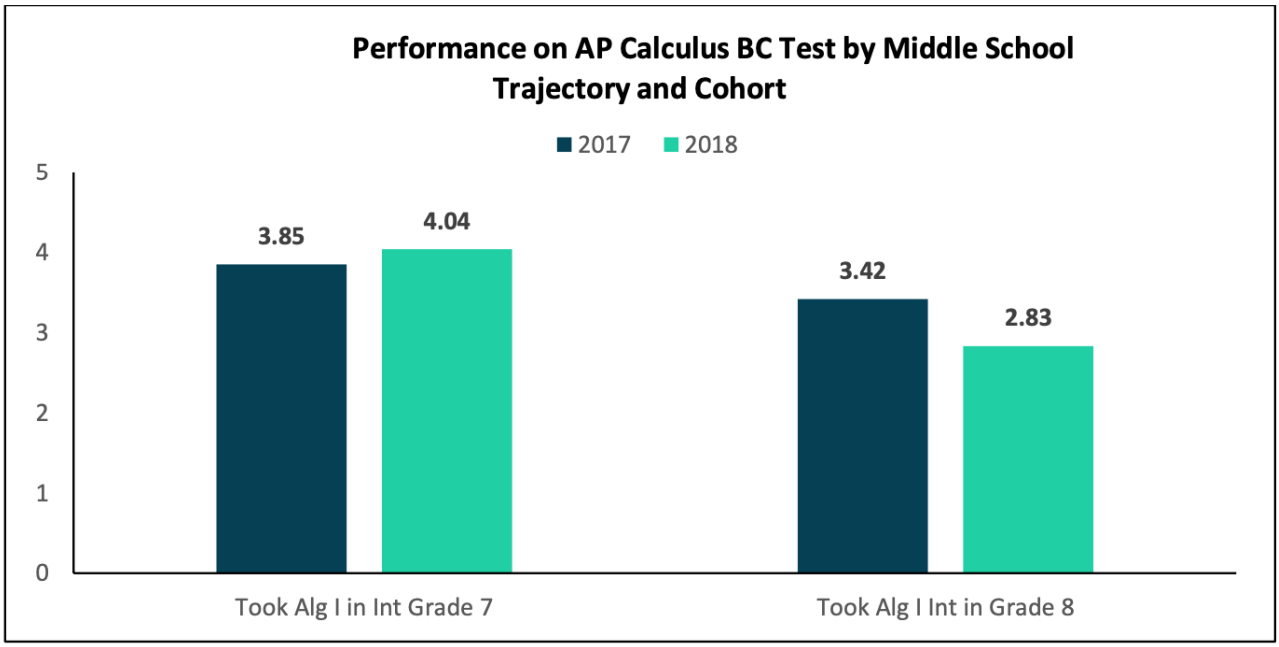


Table 39 shows that different demographic groups exhibit different levels of average academic achievement by the end of the middle school mathematics sequence. Successful completion is defined as completing the course with a B or higher and achieving a score of 500 or higher on the SOL Test. Students enrolled in the advanced classes in middle school had significantly higher success rates as compared to all students -both middle and high school students taking the course. In particular, fewer Black/African American and Hispanic students successfully complete Algebra I/Algebra I Intensified or Geometry Intensified while in middle school. Success rates are also lower for EL, SWD, and economically disadvantaged students.

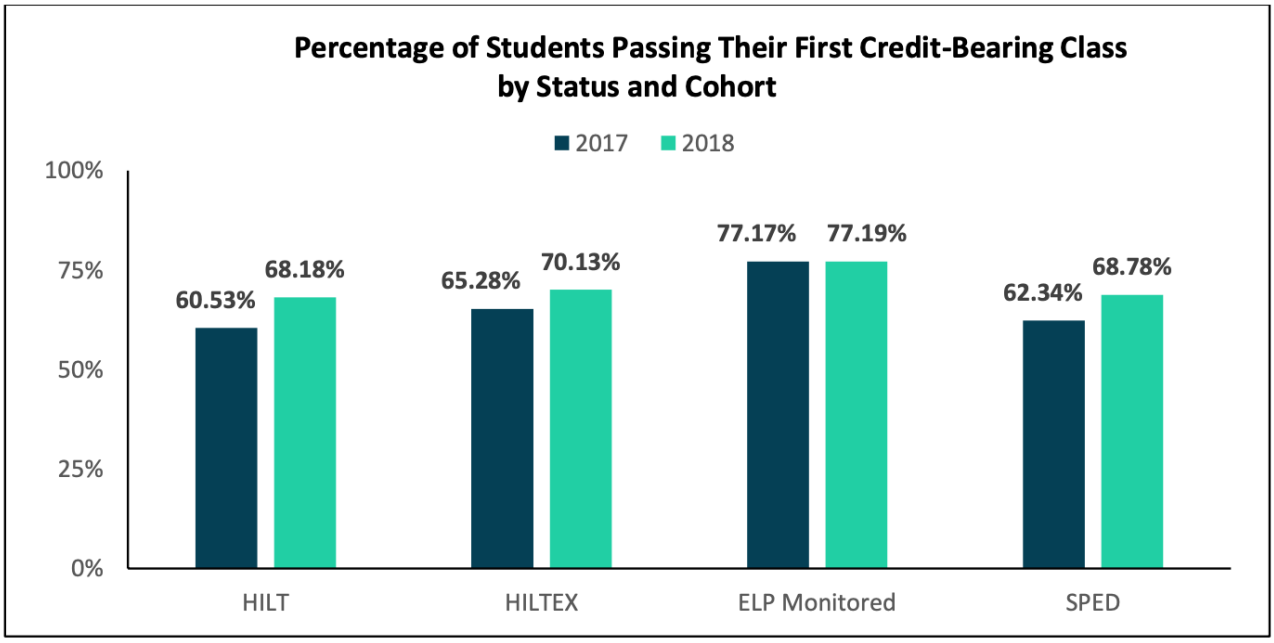
Table 39: Hanover Report: Percentage of Students Successfully Completing Algebra I/Algebra I Intensified and Geometry Intensified while in Middle School by Demographic Sub-Group, Cohort 2017

Demographic Sub-Group	% Success at Algebra I/Algebra I Intensified		% Success at Geometry Intensified	
	All Students	Students Enrolled in Alg I/Alg I Intensified	All Students	Students Enrolled in Geo Intensified
Gender				
Female	14.95%	20.73%	7.47%	69.81%
Male	11.16%	16.92%	6.90%	61.82%
Race/Ethnicity				
Asian	10.71%	15.00%	8.33%	70.00%
Black/African American	2.86%	7.69%	0.00%	0.00%
Hispanic	6.56%	13.93%	1.54%	28.57%
Other	11.86%	15.22%	8.47%	62.50%
White	19.33%	22.41%	11.43%	74.32%
English Learner Status				
LEP	3.99%	9.57%	0.72%	66.67%
Not LEP	16.57%	20.81%	9.69%	65.71%
Special Education Status				
SPED	1.13%	3.77%	2.26%	80.00%
Not SPED	15.66%	20.19%	8.26%	65.05%
Economic Disadvantage Status				
Disadvantaged	3.13%	7.91%	1.14%	44.44%
Not Disadvantaged	18.55%	21.73%	10.53%	67.68%

Table 40: Grade Level at which Students take their First Credit-Bearing Mathematics Class by EL and SWD Status, Cohort 2018

Grade Level of First Credit-Bearing Class	English Learners			Special Education Students
	HILT	HILTEX	Monitored	
Grade 8	37.04%	51.22%	50.67%	38.03%
Grade 9	44.44%	42.68%	24.22%	49.30%
Grade 10	0.00%	0.00%	1.35%	1.88%
Grade 11	0.00%	0.00%	0.45%	0.00%
No Credit-Bearing Classes	18.52%	6.10%	23.32%	10.80%
N	**27**	**82**	**223**	**213**

Figure 88: Percentage of Students Passing Their First Credit-Bearing Class by Status and Cohort



Mathematics Inventory Assessment

The Mathematics Inventory (MI) is an adaptive research-based universal screener that assesses student performance in five strands of mathematics: Numbers and Operations, Geometry, Measurement, Algebra, and Data Analysis & Probability. Student results are reported using a measure called the Quantile which indicates how well a student understands mathematics skills and concepts along a developmental continuum. MI is currently designed to measure a student's location on the Quantile Framework within their grade level. While the assessment spans grades, the precision of the tool is focused on grade-level content. Teachers use this measurement to assess progress, but more importantly, to flag students who need additional support and to guide future course selection based on skill readiness. Students in the Below Basic and Basic levels receive individualized intervention and remediation.

Proficiency Categories

The Mathematics Inventory has four proficiency categories. Students in the Below Basic and Basic categories do not demonstrate readiness for grade-level content. These students receive specific instruction to develop their mathematical skill set and concept understanding. The following tables show the percent of students by grade level in the Below Basic and Basic categories in the Fall and then the Spring from 2015-16 through 2018-19. The lower percentages of students in the Below Basic and Basic categories in Spring testing indicate the success of interventions on student performance.

Table 41: Percent of Grade 5 Students in each Mathematics Inventory Proficiency Category

	Below basic	Basic
Fall 2015-16 (n=191)	48%	37%
Spring 2015-16 (n=1,791)	16%	30%
Fall 2016-17 (n=1,821)	28%	27%
Spring 2016-17 (n=1,649)	11%	16%
Fall 2017-18 (n=2,120)	31%	26%
Spring 2017-18 (n=1,601)	12%	21%
Fall 2018-19 (n=2,072)	30%	30%
Spring 2018-19 (n=1,417)	13%	22%

Table 42: Percent of Grade 6 Students in each Mathematics Inventory Proficiency Category

	Below basic	Basic
Fall 2015-16 (n=1,656)	34%	43%
Spring 2015-16 (n=1,666)	24%	32%
Fall 2016-17 (n=1,862)	28%	38%
Spring 2016-17 (n=1,860)	16%	16%
Fall 2017-18 (n=1,828)	33%	36%
Spring 2017-18 (n=1,763)	16%	19%
Fall 2018-19 (n=2,024)	33%	32%
Spring 2018-19 (n=1,648)	15%	18%

Table 43: Percent of Grade 7 Students in each Mathematics Inventory Proficiency Category

	Below basic	Basic
Fall 2015-16 (n=1,493)	41%	36%
Spring 2015-16 (n=1,465)	22%	25%
Fall 2016-17 (n=1,746)	32%	23%
Spring 2016-17 (n=1,705)	16%	17%
Fall 2017-18 (n=1,883)	29%	23%
Spring 2017-18 (n=1,213)	22%	18%
Fall 2018-19 (n=1,690)	28%	25%
Spring 2018-19 (n=1,206)	13%	15%

Table 44: Percent of Grade 8 Students in each Mathematics Inventory Proficiency Category

	Below basic	Basic
Fall 2015-16 (n=1,399)	36%	38%
Spring 2015-16 (n=1,300)	27%	24%
Fall 2016-17 (n=1,547)	24%	28%
Spring 2016-17 (n=1,433)	20%	23%
Fall 2017-18 (n=1,675)	27%	26%
Spring 2017-18 (n=303)	41%	20%
Fall 2018-19 (n=1,666)	27%	22%
Spring 2018-19 (n=609)	25%	21%

Average Growth

Quantile growth is typically greater for younger and/or less proficient students, but may be influenced by many factors, including developmental ability and degree of instructional intervention, among others. Table 41 provides an overall view of Average Quantile Growth from Fall to Spring from 2015-16 through 2018-19. Tables 42 - 45 show the percent of students with Quantile Increase by Grade.

Table 45: Average Quantile Growth from Fall to Spring

School Year	Grade 5		Grade 6		Grade 7		Grade 8	
	# of Students	Avg. Quantile Growth	# of Students	Avg. Quantile Growth	# of Students	Avg. Quantile Growth	# of Students	Avg. Quantile Growth
2015-16	179	94	1,593	73	1,392	141	1,232	99
2016-17	1,537	178	1,721	157	1,616	136	1,341	134
2017-18	1,561	106	1,679	158	1,158	133	283	105
2018-19	1,956	112	1,947	144	1,514	135	752	92

Table 46: Percent of Grade 5 Students to Meet Average Growth Rate by Fall Proficiency

School Year	Below Basic		Basic		Proficient		Advanced	
	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth
2015-16	84	38%	68	24%	27	33%	NA	NA
2016-17	415	65%	403	66%	556	64%	165	63%
2017-18	436	65%	414	44%	544	24%	169	27%
2018-19	400	58%	404	48%	522	39%	16	63%

Table 47: Percent of Grade 6 Students to Meet Average Growth Rate by Fall Proficiency Groups

School Year	Below Basic		Basic		Proficient		Advanced	
	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth
2015-16	524	42%	685	45%	358	52%	27	37%
2016-17	451	64%	655	72%	570	80%	50	64%
2017-18	544	66%	617	69%	488	80%	40	75%
2018-19	471	69%	507	68%	517	76%	61	66%

Table 48: Percent of Grade 7 Students to Meet Average Growth Rate by Fall Proficiency Groups

School Year	**Below Basic**		**Basic**		**Proficient**		**Advanced**	
	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth
2015-16	565	62%	504	79%	302	60%	22	46%
2016-17	491	67%	377	44%	679	66%	75	57%
2017-18	418	58%	294	75%	418	68%	34	53%
2018-19	297	65%	285	73%	446	72%	118	64%

Table 49: Percent of Grade 8 Students to Meet Average Growth Rate by Fall Proficiency Groups

School Year	Below Basic		Basic		Proficient		Advanced	
	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth	# of Students	% Met Avg. Growth
2015-16	419	49%	486	69%	300	57%	27	41%
2016-17	306	58%	371	80%	520	71%	147	60%
2017-18	146	40%	62	66%	62	74%	13	46%
2018-19	229	54%	167	69%	169	66%	15	20%

RESULTS OF ADVANCED PLACEMENT AND IB TESTING

Mathematics AP Test Pass Rates

The following three tables compare the AP Mathematics Exam pass rates of APS students to the state and national pass rates.

- AP Calculus AB exam pass rates for APS students are lower than state and national averages with the exception of the 2013-14 test where the APS pass rate was slightly higher than state and national averages.
- AP Calculus BC exam pass rates for APS students show variation over the past five years with some years passing at a slightly higher rate than state and national averages and other years performing slightly lower. Last year the APS pass rate was 74% which is 6% lower than the state average and 6% lower than the national average.
- AP Statistics exam pass rates for APS students are lower than state and national averages with the exception of the 2013-14 test where the APS pass rate was 67%. Pass rates ranged from 4 – 12 percentage points lower than the national average.

Table 50: AP Calculus AB Exam Pass Rates, 2013-14 through 2017-18

Group	2013-14		2014-15		2015-16		2016-17		2017-18	
	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed
APS	208	63%	260	52%	239	49%	283	50%	302	50%
Virginia	8,901	62%	9,261	59%	9,401	62%	9,218	62%	9,374	61%
National	294,072	59%	302.532	57%	308,215	60%	316,099	56%	308,538	58%

Table 51: AP Calculus BC Exam Pass Rates, 2013-14 through 2017-18

Group	2013-14		2014-15		2015-16		2016-17		2017-18	
	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed
APS	165	83%	150	78%	163	79%	171	84%	189	74%
Virginia	4,420	81%	4,597	79%	4,771	81%	4,954	81%	5,243	80%
National	121,463	81%	118,707	80%	124,931	81%	132,514	81%	139,376	80%

Table 52: AP Statistics Exam Pass Rates, 2013-14 through 2017-18

Group	2013-14		2014-15		2015-16		2016-17		2017-18	
	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed
APS	126	67%	130	52%	137	50%	202	42%	210	57%
Virginia	6,713	54%	6,332	56%	6,752	58%	6,907	52%	6,554	59%
National	184,173	60%	195,526	58%	206,563	61%	215,840	54%	222,501	61%

Table 53 shows the AP Calculus AB Exam pass rates between 2013-14 and 2017-18 broken down by demographics. In general, the 2013-14 pass rates are much higher than the subsequent years' pass rates.

- The number of females taking the exam rises, but there is a 13 percent drop in the pass rate. For males, there is more fluctuation in the pass rate, but an improvement of 2 to 3 percent over the past four years.
- EL students have almost the fewest number of students taking the exam, second only to SWD students, and those numbers vary from year to year from a high of 12 to a low of 5 students. Pass rates fall within 6 to 12 percent of APS, state, and national pass rates - at times equal to or higher. In 2016-17, EL students pass at the same rate as their Non-EL peers and APS overall, at 50 percent. They have higher pass rates than Disadvantaged, Black, and Hispanic students, with the exception of the 2017-18 results which see a dramatic decline from 50 percent, the prior year, to 22 percent.
- Disadvantaged students have fairly consistent pass rates, pass rates falling within 2 to 3 percent of each other over the five year time period. One exception is in 2014-15 when there was an aberrant 10 percent drop in pass rates. Their pass rates are generally 20 percent below APS and state averages.
- SWD students are the group which has the fewest number of students taking the exam. The sample size is usually too small for reporting purposes. However, in 2014-15, 60 percent of SWD students pass the exam with five students taking the exam.
- Black students have pass rates below APS, state, and national pass rates by an average of 25 to 30 percent. They also have the third fewest number of students taking the exam.
- Hispanic students have pass rates below APS, state, and national pass rates by an average of 10 to 15 percent.
- White students have pass rates higher than the APS average every year except for 2017-18. Compared to state pass rates, white students have been passing at lower rates by 7 to 10

percent over the past three years. The number of White students taking the exam has been increasing over time.

- Other students have the highest pass rates of all APS students. There has been a slight increase in the number of Other students taking the exam over time.

Table 53: AP Calculus AB Exam Pass Rates by Gender, LEP Status, Economic Status, Disability Status, and Ethnicity 2013–14 through 2017–18

Group	2013-14		2014-15		2015-16		2016-17		2017-18	
	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed
Females	104	59%	137	55%	119	49%	138	47%	146	46%
Males	104	66%	123	48%	120	50%	145	52%	156	55%
Non-LEP	199	63%	248	52%	234	49%	271	50%	293	51%
LEP	9	56%	12	50%	5	60%	12	50%	9	22%
Non-Disadvantaged	181	66%	221	55%	207	51%	238	51%	263	52%
Disadvantaged	27	41%	39	31%	32	41%	45	42%	39	39%
Non-SWD	205	62%	255	51%	237	49%	279	50%	298	50%
SWD	3	*	5	60%	2	*	4	*	4	*
Asian	31	58%	33	42%	21	57%	31	48%	31	32%
Black	9	33%	17	24%	15	33%	16	25%	19	42%
Hispanic	29	45%	41	42%	33	36%	50	38%	38	37%
White	126	70%	154	58%	157	52%	168	55%	196	54%
Other	13	62%	15	67%	13	62%	18	56%	18	78%

*Sample sizes less than 5 are not reported

Table 54 shows the AP Calculus BC Exam pass rates between 2013-14 and 2017-18 broken down by demographics. In general, pass rates are higher for this AP exam.

- Females are passing below APS, state, and national averages by 2 to 10percent. The number of females taking the exam is increasing. Males are passing above APS, state and national averages by 2 to 8 percent.
- Few EL students take this exam. Pass rates are about 25 to 40 percent below APS, state, and national averages or more. They are passing at rates 30 to 40 percent below their Non-EL peers.
- Disadvantaged students see a lot of fluctuation in their pass rates with some years reflecting a 33 percent gap and at other years only an 8 percent gap between their pass rate and local, state, and national averages.
- There are too few SWD students at this level to have a reported pass rate for this AP exam.
- Asian students have a pass rate close to or above APS, state, and national averages.
- Few Black students are taking this exam and their pass rates are well below APS, state, and national averages by about 25 percent. A dramatic decline in the pass rate is seen during the 2017-18 school year.
- Hispanic students have higher numbers of students taking the exam and higher pass rates than Black students, but are still performing below APS, state, and national averages by 9 to 21 percent.
- White students perform above local, state, and national averages by 5 to 10 percent. The number of White students taking the exam has increased but the pass rate has been decreasing over the past five years.
- Other students have seen big swings in their pass rates from year to year with a high score of 90 percent in 2015-16 to a low of 64 percent the following year, 20 percent below the APS average.

Table 54: AP Calculus BC Exam Pass Rates by Gender, LEP Status, Economic Status, Disability Status, and Ethnicity 2013–14 through 2017–18

Group	2013-14		2014-15		2015-16		2016-17		2017-18	
	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed
Females	70	79%	73	71%	74	76%	81	82%	89	70%
Males	95	86%	77	84%	89	81%	90	86%	100	77%
Non-LEP	158	84%	144	80%	159	78%	166	83%	182	75%
LEP	7	57%	6	33%	4	*	5	60%	7	43%
Non-Disadvantaged	151	85%	130	83%	149	79%	158	85%	172	74%
Disadvantaged	14	57%	20	45%	14	71%	13	62%	17	65%
Non-SWD	161	83%	149	78%	161	79%	170	84%	187	73%
SWD	4	*	1	*	2	*	1	*	2	*
Asian	15	80%	21	62%	24	83%	20%	90%	16	75%
Black	7	57%	6	50%	7	43%	4	*	6	17%
Hispanic	19	68%	23	57%	17	65%	19	74%	17	65%
White	117	88%	94%	88%	105	81%	117	87%	127	79%
Other	7	71%	6	83%	10	90%	11	64%	23	65%

*Sample sizes less than 5 are not reported

Table 55 shows the AP Statistics Exam pass rates between 2013-14 and 2017-18 broken down by demographics.

- Female exam pass rates vary widely from year to year with differences of 10 to 20 percent. Male student pass rates are above APS, state, and national averages, except for the 2015-16 school year.
- There are too few EL students taking this exam to have a reported pass rate.
- Disadvantaged students have pass rates between 20 to 40 percent below APS average pass rates. The number of Disadvantaged students taking the exam has increased over the five-year span.
- SWD students have pass rates from 2 percent below APS average rates to 31 percent lower. No SWD students took the exam in the 2017-18 school year.
- Asian students see some fluctuation in their pass rates with a gap as wide as 14 percent below APS averages in 2013-14 to a 7 percent higher pass rate than the APS average in 2015-16.
- Black students see pass rates in the teens, well below APS, state, and national average pass rates. The exception is in 2017-18 when the pass rate was 33 percent.
- Hispanic students have pass rates within 3 to 7 percent of APS, state, and national rates. The only exception is a 33 percent pass rate in 2014-15 leaving a 19 percent gap.
- White students have pass rates above the APS exam pass rate across the entire span of years. Two of those years White students still performed below state and national averages.
- Other students have pass rates that fluctuated above and below APS, state, and national averages each year.

Table 55: AP Statistics Exam Pass Rates by Gender, LEP Status, Economic Status, Disability Status, and Ethnicity 2013–14 through 2017–18

Group	2013-14		2014-15		2015-16		2016-17		2017-18	
	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed
Females	60	65%	53	42%	60	53%	110	35%	108	57%
Males	66	68%	77	60%	77	47%	92	51%	102	58%
Non-LEP	122	67%	128	53%	135	50%	200	43%	202	58%
LEP	4	*	2	*	2	*	2	*	8	25%
Non-Disadvantaged	109	73%	117	55%	123	53%	181	45%	187	60%
Disadvantaged	17	29%	13	31%	14	21%	21	14%	23	30%
Non-SWD	119	67%	124	55%	131	50%	193	44%	210	57%
SWD	7	57%	6	50%	6	33%	9	11%	0	*
Asian	17	53%	16	44%	14	57%	16	38%	24	46%
Black	9	11%	4	*	8	13%	6	17%	9	33%
Hispanic	11	64%	18	33%	18	44%	25	36%	34	50%
White	81	75%	83	61%	92	52%	144	45%	131	64%
Other	8	75%	9	33%	5	60%	11	36%	12	42%

*Sample sizes less than 5 are not reported

IB Mathematics Results

The International Baccalaureate (IB) program is an internationally recognized program of studies that provides the rigor, the structure, and the experience necessary to challenge academically talented and motivated students.

The table below provides the pass rates for each IB mathematics course by year from 2013-14 through 2017-18. In general, the pass rates are very high. In Standard Level Mathematics, pass rates are between 95 and 100 percent. In Standard Mathematics, pass rates ranged between 91 and 95 percent with an outlying 80 percent pass rate in 2014-15. There is more fluctuation in the Higher Level Mathematics results with pass rates ranging from 80 to 100 percent. Fewer students take that exam.

Table 56: IB Mathematics Pass Scores by Year

Test Name	2013-14		2014-15		2015-16		2016-17		2017-18	
	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed	# Tested	% Passed
SL. Mathematics Studies	39	97%	29	97%	53	98%	51	100%	40	95%
SL. Mathematics	88	92%	54	80%	91	91%	94	95%	89	93%
HL. Mathematics	7	100%	5	80%	11	100%	4	*	9	89%

Table 57: IB Mathematics Scores by Year

Test Name	Year	# Tested	% scored 1	% scored 2	% scored 3	% scored 4	% scored 5	% scored 6	% scored 7
SL Mathematics Studies	2013-14	39	0%	0%	3%	18%	21%	56%	3%
	2014-15	29	0%	0%	3%	21%	28%	35%	14%
	2015-16	53	0%	0%	2%	4%	49%	34%	11%
	2016-17	51	0%	0%	0%	12%	43%	39%	6%
	2017-18	40	0%	0%	5%	15%	25%	4-%	15%
SL Mathematics	2013-14	88	0%	1%	7%	26%	30%	31%	6%
	2014-15	54	0%	2%	19%	17%	30%	26%	7%
	2015-16	91	0%	1%	8%	21%	20%	29%	22%
	2016-17	94	0%	0%	5%	18%	27%	30%	20%

	2017-18	89	0%	0%	7%	24%	36%	26%	8%
HL Mathematics	2013-14	7	0%	0%	0%	29%	29%	43%	0%
	2014-15	5	0%	20%	0%	20%	20%	20%	20%
	2015-16	11	0%	0%	0%	9%	36%	55%	0%
	2016-17	4*							
	2017-18	9	0%	0%	11%	22%	22%	22%	22%

*Sample sizes smaller than 5 are not reported

SECTION 3: RECOMMENDATIONS AND NEXT STEPS

CONNECTIONS WITH SYSTEMIC APS PROCESSES AND INTITIATIVES

In addition to the specific recommendations described below, APS should carefully consider this report's findings and recommendations in light of the following overarching processes, initiatives, and resources. Fundamental and systematic coordination is needed so that we can share, learn from, and build upon both our challenges and successes in a concerted manner.

- *Strategic Plan*. In the fall of 2018, the School Board adopted performance objectives for the new 2018-24 Strategic Plan. The Mathematics Office will work towards the goal of **Multiple Pathways to Success for All Students**: *Ensure that every student is challenged and engaged while providing multiple pathways for student success by broadening opportunities, building support systems and eliminating barriers. APS will eliminate opportunity gaps so all students achieve excellence*.

  The Mathematics Office's response to the evaluation recommendations align with the following objectives:
  - Embed global competencies, critical thinking, creative thinking, collaboration, communication, and citizenship into curriculum and instruction.
  - Adapt curriculum and instruction to the needs of each student. Increase meaningful inclusive learning environments for students.
  - Provide learning opportunities in a variety of settings, times, and formats that include opportunities for students to align knowledge, skills, and personal interests with career and higher educational opportunities including internships and externships.
  - Increase high-quality options for PreK-12 instructional models within and beyond neighborhood schools.
  - Ensure equity of access and opportunity across all school programs. Address unconscious racial bias throughout APS.

  Performance objectives for this goal include:
  - Increased achievement for all reporting groups on district and state assessments shows progress toward eliminating the opportunity gap.
  - All students will make at least one year's worth of growth as measured by federal, state, and/or district assessments.
  - Historically over-represented and under-represented groups accessing services will be aligned with student need and proportionate with demographics.
  - All graduates will have engaged in at least one experience that demonstrates productive workplace skills, qualities, and behaviors and may include a work-based experience (internships, externships, formal job shadowing, etc.).

    - At least 80% of students with disabilities will spend 80% or more of their school day in a general education setting.

- *Virginia Graduation Requirements*. The new state diploma requirements call for Virginia graduates to have acquired knowledge, skills, behaviors, and capabilities that qualify as attributes of a career-ready student, and for students to develop the following competencies: critical and creative thinking, communication, collaboration, and citizenship (community and civic responsibility).

RECOMMENDATIONS & STAFF ACTION PLAN

Recommendation #1: Provide growth and leadership opportunities by providing meaningful, high-quality, and relevant professional learning opportunities to support retaining and advancing high-quality employees.

- Continue to strengthen teacher content knowledge through job-embedded professional development provided by mathematics coaches, APS Content Academies, and university partnerships
- Strengthen the utilization of best practices through professional learning around
    - Mathematics Workshop
    - Content academies
    - Principal Institutes
    - Mathematics coaching
    - Lead Teacher & Department Chair development
    - Secondary Mathematics countywide learning opportunities
- Co-teaching in collaboration with the Office of English Learners, the Office of Special Education, and the Office of Gifted Services
- Create a universal professional learning plan for teachers, coaches, and administrators
- In collaboration with the Office of English Learners and the Office of Special Education, encourage mathematics teaching staff to earn educational credits and/or an endorsement in the areas of English Learner Education and Special Education to improve teaching pedagogical practices for all students
- Support teachers and coaches working toward Mathematics Specialist endorsements

Goals	Measures of Success	Action Steps	Timeline
• Create a universal professional learning plan/sequence for all K-8 teachers who teach and support mathematics. (Math coaches & building administrators)	• Consistent enrollment and completion of recommended sequence of professional learning within time frame articulated in the Math Professional Learning Plan. • Consistent implementation of instructional approaches across schools through observations using a standard observation protocol.	• Define the sequence of professional learning for various stakeholder groups. • Determine the time frame required for each component of the professional learning plan for each stakeholder group. • Refine professional learning offerings based on school-level and stakeholder group needs. • Collaborate with Professional Learning Office to create a communication plan.	Summer 2020
• Create professional learning plan for HS teachers and those who support HS mathematics.	• Consistent enrollment and completion of recommended sequence of professional learning within time frame articulated in the Math Professional Learning Plan. • Consistent implementation of instructional approaches across schools through observations using a standard observation protocol.	• Define the sequence of professional learning for various stakeholder groups. • Determine the time frame required for each component of the professional learning plan for each stakeholder group. • Collaborate with Professional Learning Office to create a communication plan.	SY 2020-21
• Develop a leadership plan for Secondary Math Lead teachers,	• Enrollment in college course work around Math Specialist	• Determine expectations for math leaders regarding	SY 2020-21

Math Coaches, or other math leaders in APS.	endorsement and/or special populations. • Professional Learning offerings led by Math leaders within APS.	delivering professional learning at their building or countywide. • Collaborate with post-secondary institutions to provide opportunities for Math Coaches and Math Leads to pursue endorsements.	

Recommendation #2: Allocate staffing for more Mathematics Coaches at the elementary and high school levels and sustain allocations at the middle school level. Mathematics Coaches work to

- Improve student achievement and address the opportunity gap through the improvement of instruction
- Work with administrators, teachers, students, parents and the community toward meeting APS mathematics goals
- Support the self-directedness of individual teachers and/or teams of teachers through coaching, consulting, and collaborating
- Assist teachers in interpreting data and with incorporating strategies to improve student achievement and instruction
- Promote teachers' delivery and understanding of the curriculum through collaborative long-range and short-range planning
- Facilitate teachers' use of successful, research-based instructional strategies, including differentiated instruction for diverse learners
- Meet regularly with school administration to review data and plan
- Collect data through observation of instruction to support teachers in planning and reflecting
- Engage in research-based professional development and applies learned professional development practices
- Assist in development of curriculum and assessment resources
- Prepare and delivers staff development related to APS Mathematics Office
- Support the work of the school's leadership team by representing the mathematics lens and advocating for high quality instructional practices
- Engage in his/her own learning and planning to prepare for support of teachers and teams
- Promote equitable teaching practices

Goals	Measures of Success	Action Steps	Timeline

• Continue to advocate for the need for and benefits of math coaches at all levels.	• Currently 16 Elementary Principals have reallocated staffing funds to increase math coach positions at their schools indicating the need. Other Principals expressed the desire to reallocate staffing but were unable. • Other specialized teachers including RTGs and Reading Specialist have at least 1.0 allocation at all elementary schools • Survey results from Program Evaluation indicate high levels of collaboration with math coaches at K-8 levels. • Survey results from Program Evaluation indicate limited collaboration between math teachers and any other specialist/resource teacher in their schools	• Continue to be strategic in supporting the development of coaches • Work with Principals with reallocation needs. • Provide PL for other staff who support math teachers in collaboration with other offices (EL, Gifted, SpEd)	SY 2019-20

Recommendation #3: Develop curriculum guides and documents that integrate instructional approaches focused on improving student achievement in all demographic groups, in collaboration with other Teaching and Learning Offices, such as Gifted, English Learner, Special Education, Personalized Learning, and the Arlington Tiered System of Support to

- Provide research-based curricular materials aligned to current standards
- Deploy research-based interventions and curricular support for targeted groups such as English learners, students with disabilities, and students above or below grade level
- Offer professional learning to promote personalized learning opportunities in the classroom
- Provide opportunities that support teacher with depth and complexity in instruction
- Provide intentional opportunities for students to read, write, speak, and listen within curriculum documents and resources

Goals	Measures of Success	Action Steps	Timeline
• Collaborate with other Teaching and Learning Offices, such as Gifted, EL, Special Education, Personalized Learning, and ATSS to refine existing curriculum documents.	• Curriculum documents will have embedded supports for a variety of learners. • Curriculum documents will have embedded language supports. • A majority of teachers surveyed will report that they are regularly using APS curriculum documents.	• Work with other offices to create committees which includes math teachers, EL teachers, SpED teachers, and gifted teachers to refine curriculum documents as described. • Determine expectations for final product. • Determine a timeline for work to be completed.	SY 2019-20 through SY 2020-21
• Review with committees research-based curricular materials that are aligned with current VDOE Math standards and support all learners including interventions and extensions for purchase.	• A majority of teachers surveyed will report that they are regularly using APS provided resources.	• If resources are approved in the budget then begin RFP process. • Embed new resources in existing curriculum documents. • Survey math teachers post-adoption to determine use of new curricular resources.	SY 2019-20 through SY 2020-21

Recommendation #4: Provide multiple pathways for success to all students by creating access to advanced and college level courses in a variety of ways.

- Design a flexible Mathematics Program that includes modules, course options, and courses with a compacted curriculum which allow students to demonstrate readiness for college level classes or advanced coursework at their own pace
- Create a comprehensive vertical articulation that leads to increased depth and complexity at the elementary level with the goal of comprehensively preparing students for more rigorous middle school coursework
- Create a comprehensive vertical articulation that leads to increased depth and complexity at the middle school level with the goal of comprehensively preparing students for more rigorous high school coursework
- Explore additional ways to compact high school course material
- Utilize technology to augment instruction and support access to advanced mathematics courses
- Work with all stakeholder groups to ensure common understanding of the role of additional depth and complexity and course progressions, including
    - Students
    - Families
    - Teachers
    - Directors of Counseling and Counselors
    - Administrators

Goals	Measures of Success	Action Steps	Timeline
• Design a flexible Math Program that includes modules, course options, and courses with a compacted curriculum which allows students to demonstrate readiness for college level classes or advanced coursework at their own pace.	• Increased student success and retention rate in above grade level mathematics courses.	• Explore additional ways to compact high school course material. • Create a comprehensive vertical articulation that leads to increased depth and complexity at the elementary level with the goal of comprehensively preparing students for more rigorous middle school coursework • Create a comprehensive vertical articulation that leads to increased depth and complexity at the middle school level with the goal of comprehensively preparing students for more rigorous high school coursework	SY 2020 - 21 through SY 2021 - 22