



## Educating Mathematical Thinkers: Park School's Mathematics Program

Ever since the National Council of Teachers of Mathematics issued new standards in 1989, there has been a debate between back-to-basics instruction and teaching for understanding. The debate is often posed as an either/or choice, a stark dichotomy. At Park, we reject that dichotomy. In line with leading mathematics educators, we believe that to become strong mathematical thinkers, students need both mastery of fundamental skills and procedures and conceptual understanding.\*

Park's curriculum produces **independent, resourceful, and rigorous thinkers** who succeed in mathematics. Enrollment in upper level math courses is high: 56% of Park's current senior class is currently studying or has studied Calculus. 95% elect to take four years of math. Park students have a record of achievement in advanced level mathematics, and 27% are enrolled in a post-calculus elective. 81% of sophomores and juniors who took the AP Calculus AB exam over the last five years scored 5, the highest possible score. In Maryland Mathematics League contests over the last ten years, Park placed 1st among private schools in the Baltimore area for seven years, 2nd for the other three years.

\*Richard Rothstein, "A Sane Position Amid Math's Battlefield," *The New York Times*, A18, June 27, 2001

## The Approach

At Park, conceptual understanding and mastery of basic skills are linked, not separated. Students' learning of standard mathematical procedures is grounded in an understanding of why and how these procedures work. From pre-kindergarten on, students learn **strategies** to solve problems rather than memorize formulas. The youngest children begin to **look for patterns** among numbers or in geometric forms. They **visualize** problems by making drawings, charts, or graphs. They work with manipulatives to understand essential number concepts. They learn to **estimate** to check on the reasonableness of their solutions. As students move into higher levels of mathematics, these strategies continue, but others are added: for example, **taking ideas apart** (breaking a large or complex problem into smaller parts or cases) or **using inverse thinking** (working backwards). In total, we term these strategies **habits of mind**. They are essential to mathematical thinking.

Students learn and practice habits of mind in a variety of ways, including direct instruction. However, most typically, students learn them through **investigations** (problems and projects), which they work on in small groups. This active approach to learning involves students in sharing ideas, trying out strategies, and working through problems to accurate solutions.

## The Content

Park covers the content common to traditional programs—and content beyond what those programs offer—but in a different sequence. Park's program integrates different strands of mathematics rather than separating them (e.g., into the traditional Algebra and Geometry high school sequence). The aim is to create flexible thinkers who can draw on different aspects of mathematics in solving real world problems.

*Lower School:* Students work on computational understanding and skills, ranging from Whole Numbers through Fractions and Decimals. They also have extensive exposure to Geometric Concepts, Algebra, Measurement, and Data Analysis.

*Middle School:* The program begins with an intensive focus on applications of fractions, decimals, and percents, and moves into concepts and interrelationships among Arithmetic, Geometry, Algebra, Probability, Statistics, Programming, Trigonometry, and Spreadsheets.

*Upper School:* Traditional content of algebra, geometry, trigonometry, and pre-calculus is covered. Students then choose from an array of electives including Calculus, Advanced Calculus, Advanced Discrete Mathematics, Abstract Algebra, and Linear Algebra. Other offerings include introductory courses in Calculus, Statistics, and Discrete Mathematics.

## Opportunities for Advanced Work

*Lower School:* The emphasis on small group work provides flexibility to accommodate different paces and levels of mastery, including a structure for challenge work. In addition, after school clubs, such as Math Games and Math Circle, provide opportunities for enrichment.

*Middle School:* Structures provide opportunities for a faster pace or greater depth in exploring topics. Students are clustered by ability in sixth grade and grouped in seventh and eighth grades according to their facility with abstract concepts and demonstrated work habits. Extension work challenges students and varies the curriculum as needed to accommodate advanced students.

*Upper School:* The program has the scope to take students as far as they can go. There is great flexibility in both the range of courses taught and students' pace in moving through the program. Students are grouped by demonstrated interest and ability; those with particular talent and interest in mathematics cover the standard algebra/geometry/pre-calculus curriculum by the end of tenth grade. This sequence allows students to take two years of college calculus (Calculus and Advanced Calculus) before leaving high school. Students can carry their mathematics study further by taking advanced college-level courses such as, Abstract Algebra and Linear Algebra.

## The Outcomes of Park's Program

The proof is in the numbers. Park students continue their study of mathematics to advanced levels and perform competitively on a variety of national and state assessments.

### *AP Calculus AB Test Results (college level course)*

- 81% of sophomores and juniors from the last five years who took the AP Calculus AB exam scored 5, the highest possible score.
- 99% scored 3 or higher (the College Board standard for college credit or advanced placement in college courses).

### *AP Calculus BC Test Results (upper level college course)*

- 75% of students from the last five years who took the AP Calculus BC exam scored 5, the highest possible score.
- 100% scored 3 or higher.

### *SAT Scores*

- Over the last five years, the mean Mathematics SAT score was 633.

### *SAT II Subject Exam Scores*

SAT II tests measure mastery of content taught in mathematics programs.

- Over the last five years, the average score for Park students on the Mathematics II (higher level exam) was 685.

### *NAEP Test Results*

The National Assessment of Educational Progress measures the performance of students in the United States and compares their achievement to that of students internationally. Park administered an NAEP test to all eleventh graders.

- In all categories of content, Park students performed significantly above the national average. Difference was greatest in areas which measure traditional skills (numbers and operations, measurement, and algebra).
- In all categories of process (conceptual, problem solving, and procedural), Park students performed significantly above the national average. Difference was greatest in procedural competency (traditional skills) and in problem solving.

### *Maryland Mathematics League Results*

The Maryland Mathematics League sponsors statewide contests in which over 70 schools participate, including leading public and independent schools. The test evaluates mathematical competency and conceptual understanding at a high level. A number of schools coach students for this competition; Park does not.

- Park has placed 1st among private schools in the Baltimore area for seven of the last ten years, 2nd for the other three years.
- In 2005 and 2007, Park placed 1st among independent schools in Maryland and Washington DC.
- Students who have come through our Lower and Middle School math programs are consistently Park's highest performers.



## The Faculty

Teaching an ambitious mathematics program requires exceptional teachers. Consider the following:

- Average teaching experience of Park's mathematics faculty is 22 years.
- All Park Middle and Upper School math teachers have substantial formal training in mathematics. One has a Ph.D., one has a dual master's degree, and eight have master's degrees or have done substantial graduate coursework.
- Minimum qualifications for an Upper School mathematics position include the ability to teach courses through Calculus and Abstract Algebra, upper level college courses. Only a fraction of candidates seeking mathematics positions meets this requirement; Park recruits nationally—and sometimes internationally—to find highly talented men and women.
- Over half of Park's mathematics faculty have department chair experience, including several who chaired two or more departments at other private schools before coming to Park.
- Math faculty have come to Park from leading independent schools and universities, including St Paul's (NH), Isidore Newman (LA), Poly Prep (NY), St. Mark's (MA), Thacher (CA), University of Chicago, and State University of New York at Stony Brook. Park's faculty have taught the International Baccalaureate program and other international programs at schools in Brazil, Colombia, and Puerto Rico.
- Park teachers from all three divisions participate in professional activities. They have offered training workshops for teachers at other schools, been presenters at the National Association of Independent Schools conferences, published in professional journals, and served as consultants to the American Association for the Advancement of Science.

## Curricular Work: Developing a K-12 Program

Developing an outstanding mathematics program requires extensive professional development work by faculty. Park's distinctive FACA (Faculty and Curricular Advancement) program has supported 15 intensive summer projects in mathematics. In addition, Park has supported training of Lower School teachers through multiple institutes and in-house workshops. Work has included the following:

- Cross-divisional projects to implement and coordinate a coherent PreK-12 program.
- For Lower School, projects focused on number skills, to delineate essential concepts and grade-to-grade progression.
- For Middle School, creation of textbook supplements to reinforce algebraic concepts and skills, and curriculum for all grades.
- For Upper School, writing an original series of texts now in use in the 9th – 11th grades.
- Implementation of *Mathematica* software for teaching Calculus.
- Development of tools to focus instruction on the habits of mind central to mathematical thinking.

## Summary

Park School has a coordinated PreK-12 mathematics curriculum. Opportunities for advanced work are provided in Lower, Middle, and Upper Schools. Inspired by an exceptional faculty, Park students enroll in upper level courses and achieve at high levels on standardized tests and in math competitions. Following graduation from Park, students are prepared and motivated to continue their study of mathematics in college and to pursue a variety of professions which require a strong mathematics background.