

Math Instruction



Introduction

There is an urgent need to improve the performance of Boston Public Schools (BPS) students in mathematics at all grade levels. Mathematics is unforgivingly cumulative, so it is best that a strong foundation be laid in this subject from a very early age. This preparation is vital; access to a college education leading to careers in high technology and other math- and science- dominant fields can be gained only by those who demonstrate high levels of competence in mathematics in high school. Gone are the industrial jobs that once sustained many a public school graduate. Jobs in today's service economy are poorly paid and come with scant benefits. To earn a decent living, students must successfully complete some form of postsecondary education. What is more, with the growing prevalence of statistical analyses in every area of life, basic mathematical literacy is necessary merely to understand news reports, exercise one's

political franchise, or otherwise function as a good citizen. The school system's responsibility in this area is intensified by the fact that many parents were themselves not successful in school mathematics and are unaware of its increasing importance for their children's future.

The Need for Change

Student Outcomes

While student performance data have, for the most part, been moving in the right direction, BPS faces very substantial challenges in mathematics education.

BPS student performance on the MCAS improved between 2001 (the first year the BPS math plan was implemented) and 2005 for fourth, sixth, and tenth grades, as shown both by reduced failure rates and by improved

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percentages of students scoring at or above proficient levels.

Yet, in 2005, roughly one in two sixth and eighth graders failed the MCAS, as did close to one in three fourth and tenth graders. Statewide, 39% of eighth graders, 41% of fourth graders, and 46% of sixth graders scored proficient/advanced on the MCAS, compared to fewer than 25% of Boston fourth, sixth, and eighth graders. The BPS eighth grade failure and proficiency rates were basically unchanged between 2001 and 2005 (an initial failure rate of 54% fell only four percentage points, and the percent proficient or advanced increased only three percentage points).

The data reveal little improvement in the performance of special education students. It is difficult to analyze the performance of English language learners (ELLs), due to the dramatic changes caused by enactment in 2002 of Question 2, after which the number of students categorized as limited English proficient was roughly halved. ELLs did remarkably worse on the math MCAS in 2005 than those designated as limited English proficient in 2003.

Fourth and eighth grade students made statistically significant gains on the National Assessment of Educational Progress (NAEP) between 2003 and 2005. Boston's gains at both grade levels exceeded the national average in the same period. Black students made gains on both the NAEP and the MCAS; however, the achievement gap between

their performance at or above proficiency and white students' is essentially unchanged on either test. Between 2001 and 2005, eighth and tenth grade Latinos showed greater progress than eighth and tenth grades whites in achieving at or above proficiency levels on the MCAS.

In 2005, BPS Black and Latino college-bound seniors scored 402 and 409, respectively, on the math portion of the SAT, versus 559 for BPS whites and 520 for all seniors nationwide. In 2005, only 264 out of a total of nearly 8,500 BPS 11th and 12th graders took the advanced placement math exams; however, this represented an increase of 19% over 2004. Only 16 of 33 BPS high schools offer any advanced placement exams.

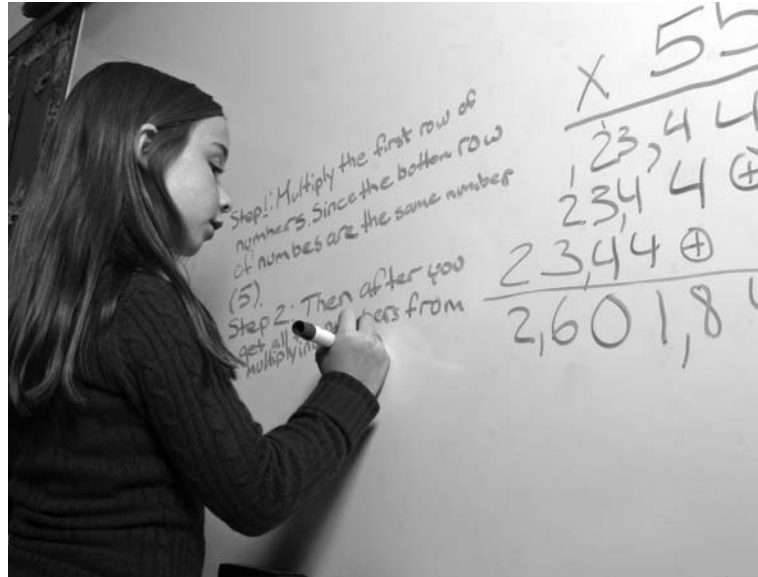
Explaining Student Outcomes: Areas for Examination

There are numerous reasons why the significant resources BPS has devoted to improving math instruction over the past five years have not yet yielded desired performance results. Areas that need examination are the following:

Curriculum

Students' mathematical knowledge has been improved by the adoption of districtwide curricula that has more challenging content and clearer sequencing and by the introduction of firmer expectations for what will be taught at the middle and elementary levels. However, there are serious problems with the current curricula.

- **High school:** After initially adopting a standards-based curriculum, BPS's office of secondary math switched back to a traditional curriculum. Our committee's understanding is that this decision was made because gaps in the standards-based curriculum caused students to be ill-prepared for the MCAS and other standardized tests. However, the decision was made without input from teachers and other stakeholders. The traditional curriculum now being used does not engage students' critical thinking skills as well as the elementary and middle school curricula do.



- **Elementary school:** The elementary curriculum has failed to address a dramatic lack of fluency in recall of basic addition and multiplication facts and has given students fewer, not more, efficient and reliable strategies for multiplication and division. Moreover, the curriculum is painfully weak in its treatment of place value, a critical concept for understanding the number system, especially as students begin working with decimal fractions.
- **Vertical integration:** BPS does not appear to have a vision of a mathematics curriculum that integrates concept and skills development from kindergarten through twelfth grade. The disjointed approaches to critical topics and the differences between the elementary and middle school curricula and between the middle and high school curricula have created holes in students' mathematical knowledge. These discrepancies are most acute between

middle and high school. Lack of collaboration and communication between the office of elementary mathematics and the office of secondary mathematics exacerbates the problem.

Professional Development

Five years ago, the BPS adopted a new teaching approach for mathematics, the workshop model, in conjunction with standards-based curricula for elementary, middle and high school. Substantial training in both implementing the workshop model and improving knowledge of mathematical content has been made available to middle and elementary teachers (it appears there has been less support available to high school teachers). Yet, because participation in this professional development is not strictly mandatory, there are still significant gaps in knowledge of mathematical content and pedagogical skill for many BPS math teachers.

At the elementary level, all teachers of mathematics are expected—but not required—to complete a curriculum institute and at least three Developing Mathematical Ideas (DMI) seminars.



Out of a total of 2000 elementary teachers, just 150 have completed the expected professional development. Much larger numbers have completed part of the training (1,400 have completed the curriculum institute, 1,350 the first DMI seminar, and 900 the second). Specific information on the extent of teachers' participation at the middle and high school levels was not available.

- *Differentiated instruction:* There is currently no clear plan for how to address the wide range of mathematics readiness of students in the average BPS classroom. A plan for special education students is only now being crafted. It appears that a math-specific plan for ELLs is not yet under consideration. Students in 17 of 30 district high schools have no access to advanced placement math classes.
- *Math Coaching:* Elementary schools whose principals have used math coaches effectively

for professional development have seen sizeable gains in student achievement on district assessments and on MCAS. Middle and high school teachers have also benefited from coaching using the Collaborative Coaching and Learning model for the last two years and from a more intensive approach to coaching for two years prior to that.

Unfortunately, funding for coaches is diminishing, and good coaches are very hard to find. Only 30 elementary schools, or 40% of the BPS total, will have math coaches next year (data on high and middle schools was not available). Another challenge is how to sustain contact between coaches and a critical mass of teachers in each school at every grade level. Beginning this fall, coaches will report to principals, who may or may not be effective math instructional leaders with the expertise necessary to appropriately evaluate the coaches' work.

Accountability

The system for ensuring that principals and headmasters are effective instructional leaders and math teachers are effective instructors must be strengthened.

Although principals and headmasters are expected to be instructional leaders in math, it is unclear how many actually understand and fulfill this role or how they are held accountable for fulfilling it. While the elementary math office has developed a range of supports for principals, participation is voluntary, leaving the principals who may need the support the most not necessarily taking advantage of it. The elementary math office states: "Math coaching is most effective when there is a principal who ensures that all teachers are using the elementary math curriculum fully, all teachers are participating in the

expected professional development, and all teachers are expected to collaborate with the math coach.” However, it is unclear how many principals are currently meeting this standard and what the district is doing to support and compel those who are not.

Although the offices of elementary and secondary mathematics each have several program directors to evaluate teachers, only those at the high school level have the authority to do so directly. Elementary program evaluators provide feedback on teachers to principals. There is no rubric to guide elementary school principals in how to evaluate math teachers, and the metric used at the secondary level should be strengthened.

Finally, while principals can and do instruct teachers to participate in professional development during the school day, there is no absolute requirement for teachers’ participation in the professional development provided by the system.

Cultural Competence

In mathematics, as in other subjects, the gap that exists between the cultures of most teachers and those of students and their families is a barrier to establishing the mutual respect that facilitates learning.

Family Involvement and Support

BPS needs to help counter the belief, still pervasive in our culture, that it is acceptable not to have a strong grasp of mathematics. BPS must

make much more vigorous efforts to educate parents about the importance of competence in mathematics for their children’s future and how they can support the development of that competence at home.

Vision of Change

In our vision of successful mathematics education, every teacher will encourage students to think deeply about mathematics and to discover for themselves the relationships and structures that are at the heart of the discipline. Teachers will skillfully probe students’ thinking and facilitate their discussion of mathematical concepts. At the same time, careful attention will be paid to ensuring that students are developing fluency in computation and symbolic manipulation.

Students will see mathematical inquiry as a tool to explore their world and will use real-world problems in the development and application of mathematical ideas. They will have a sense of confidence about, and feel ownership of, the mathematics they are learning, and will be committed to working hard to master new ideas, believing that they will be successful if they are diligent. The classroom will be an environment in which students feel comfortable taking risks. Schools will foster a love of mathematics through math teams, clubs, and competitions.

Each mathematics teacher will be well prepared, possess the appropriate credentials, and have a deep understanding of the material being taught,

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its underlying concepts, and the more advanced material that arises from those concepts. All teachers will be familiar with the obstacles students encounter in understanding the material they are teaching and will have mastered a variety of strategies to help overcome those barriers.

Teachers will value the cultural background and varied strengths and knowledge of each student and will establish a respectful, cooperative classroom culture in which considerate behavior that promotes learning is the norm. They will employ successful strategies for differentiated instruction and for supporting special education students and ELLs; these strategies, along with appropriate teaching materials, will maximize learning for all students. Schools will utilize community-based organizations and higher education partners to offer additional support to students who are behind.

With the help of family and community engagement teams, schools will understand the cultures of their students' families and help them become involved in supporting student learning. Parents and community partners will be informed about curriculum, teaching approaches, and the importance of students' performing well in mathematics in general and on the MCAS in particular. There will be workshops for parents on fostering good study habits and on the mathematics their children are being taught.

Although the BPS will make sure that students are prepared for the math MCAS, especially in the 10th grade, the overall approach of teachers, principals, and administrators will be guided by the nationally recognized principles and standards set by the National Council of Teachers of Mathematics in 2000. Students in every high school will have access to precalculus and calculus courses. Curriculum materials will be rich in

challenging and engaging problems that develop concepts from, and apply them through, realistic problem solving, while also providing effective models for more abstract material. Teachers will have access to a copious supply of practice problems that review current and previous material and expand student understanding. Teachers will use multiple types of formative assessments, get timely feedback, and have designated times for re-teaching and for providing individualized support.

All the above elements will result in the overwhelming majority of students scoring at the proficient level on the math MCAS. The achievement gaps among racial groups, between ELLs and native speakers, and between regular and special education students will be minimized. All but a handful of students will pass Algebra II before graduating, and the majority will pass precalculus. High school seniors and juniors from all backgrounds will achieve high rates of success in advanced placement math courses.

Recommendations for Change

Strengthen the Teaching Force

- Make it a top priority to recruit, support, and develop pedagogically strong teachers who have a deep and flexible understanding of mathematics, especially at the high school level. We recognize that math is a particularly difficult area in which to recruit and retain strong teachers, but there are individual principals who are succeeding in doing so. It is especially pressing that BPS develop and implement stronger system-wide strategies for reaching this goal because a large number of teachers will be retiring in the next few years.



- Institute a plan for elementary teachers to specialize either in math and science or in language arts and social studies, so that teachers can build expertise in targeted areas. The Boston Teacher Residency program would be an excellent place to prepare elementary teachers to specialize in one of these subject pairs.

Create Strong Accountability Systems

- Develop a clear set of instructional leadership expectations in math for principals and ensure that these expectations are fulfilled through a training, support, and evaluation system. Set and enforce expectations for teacher participa-

tion in professional development and delivery of mathematics instruction in the classroom.

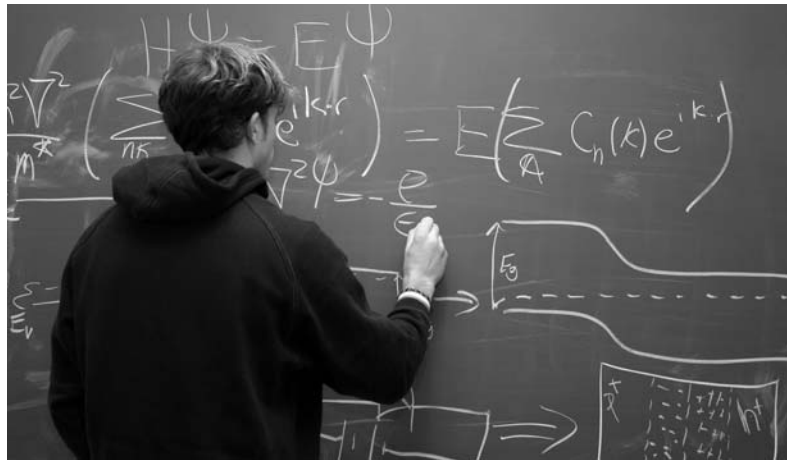
Improve Curriculum

- Using an inclusive decision-making process, select a standards-based high school curriculum to replace the current traditional curriculum. Several existing curricula are being revised to address deficits in practice problems and fill gaps in content. A new curriculum currently in development by Educational Development Center, Inc. might address Boston's need for a standards-based curriculum that is more closely aligned with the traditional American high school course structure.
- Implement comprehensive training for high school teachers in the workshop approach.
- Rapidly expand work begun this year to improve the elementary curriculum to ensure students' mastery of basic addition and multiplication facts.
- Immediately train teachers to facilitate elementary students' development of efficient and reliable strategies for solving multi-digit multiplication and division problems, through deepened understanding of the current curriculum, or the use of supplementary materials. To strengthen elementary students' understanding of place value, implement a supplemental instructional program, preferably manipulative in nature, or provide intensive training on the latest edition of the

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Investigations in Number, Data, and Space curriculum, once it has been ensured that this version addresses the issues outlined above.

- The math department should lead an effort to align kindergarten through 12th grade math curricula, addressing gaps, overlaps, misalignment with MCAS, and the transitions between elementary and middle school and middle and high school. This initiative should take advantage of work in this area by the curricula publishers, the Massachusetts Department of Education, and other school districts.



Require Comprehensive Professional Development

- Require participation in professional development workshops that support standards-based pedagogy and that teach content, especially for high school teachers. Allot workshops substantial chunks of time, preferably off site, to make certain that teachers are fully engaged. Ensure that workshops are supplemented by briefer follow-up meetings and on-site coaching. Provide opportunities for math teachers to learn from each other and work with their colleagues across the district.

- Improve the cultural competence of teachers, principals, and other administrators by training them to respect their students' backgrounds and to utilize the strengths students bring to the classroom. Provide teachers with effective strategies to address student weaknesses, nurture strengths, and establish trust and cooperation in the classroom.
- Train teachers in strategies for engaging and supporting students at a range of achievement levels. Ensure that special education and ELL teachers are included in professional development, with a particular focus on differentiated instruction and math content.

Reinvigorate Math Coaching

- Launch a major initiative to reinvigorate math coaching. Energetically renew efforts to attract funding for coaching. Recruit strong coaches

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to support teacher leaders. Provide math coaching support for every school. Invest heavily in expanding time for joint planning for teachers. To supplement individual coaching sessions, promote sharing of best practices among teachers. Ensure continued support and training of coaches by the offices of elementary and secondary math.

Expand Family Involvement and Support

- Dramatically increase outreach to parents by sponsoring events based on mathematical activities and offering training in math to parents. The offices of elementary and secondary mathematics should support schools in these efforts and coordinate with the family and community engagement department to ensure that parents across the district have access to these events and trainings. Successful fledgling efforts in this area at the elementary and middle school levels must be greatly expanded to eventually include every school.

Provide All Students with Access to Advanced Math Courses

- Provide pre-calculus, calculus, and advanced placement courses (Calculus AB, Calculus BC, and statistics) for every student who is prepared by increasing the number of teachers qualified to teach these courses, through cross-registration with other district high schools or colleges, and through on-line access. BPS must prepare students for these courses by improving the mathematics instruction in the earlier grades and by providing individualized tutoring and remediation.

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