ASSESSING THE STATE OF STEM IN BOSTON

BOSTON STEM NETWORK

CONTENTS

Assessing the State of STEM in Boston

SECTION I:

INTRODUCTION

"Science is fundamental to education because it is through scientific inquiry that students understand how to solve problems and ultimately how to learn. So it's tragic that our students are only grasping the basics and not doing the higher-level analysis and providing written explanations needed to succeed in higher education and compete in a global economy."

David Driscoll, chairman of the National Assessment Governing Board (NAGB) — which sets policy for the National Assessment of Educational Progress (NAEP) — and former Education Commissioner for Massachusetts.[1]

In the 2010 state plan for science, technology, engineering, and math (STEM), ***A Foundation for the Future: Massachusetts' Plan for Excellence in STEM Education***, the Governor's STEM Advisory Council outlines five quantitative goals with key benchmarks for the Commonwealth to work toward through 2015. These goals are intended to address the concern that students are not fully prepared to participate and lead in an innovative, high tech, high skill economy, and they focus the work of the eight regional STEM networks, of which Boston is one. In July 2012, the Council approved a sixth goal recognizing the importance of alignment with workforce demands. Section V of this report, Quantitative Measures, explains each of the Commonwealth's goals in detail and addresses the metrics that we are using locally to measure achievement.

Goals of the Governor's STEM Advisory Council

1. Increase student interest in STEM

2. Increase STEM achievement among Pre-K through 12 students

3. Increase the percentage of students who demonstrate readiness for college-level study in STEM fields

4. Increase the number of students who graduate from a postsecondary institution with a degree in a STEM field

5. Increase the number of STEM classes led by effective educators, from Pre-K through 16

6. Align STEM education programs with the workforce needs of key economic sectors

This report also identifies qualitative goals in the areas of community engagement, academic coherence, educator development, and STEM businesses and professionals. Section III, Current Initiatives, describes the Boston Public Schools' strategies as well as the work of the STEM Network in these areas.

In pursuit of these priorities identified by the state, the Boston STEM Network organized into three task forces: Career Awareness, Out-of-School Time, and Measurement.

Goals of the Boston STEM Network

Career Awareness

- Identify, promote, and expand opportunities for students, teachers, and families to understand the connection between STEM education, career, and income;
- Foster identity-building experiences for young people so that they begin to see themselves as scientists, mathematicians, and others on their way to becoming STEM professionals.

Out-of-School Time

- Build the capacity and leverage the efforts of Boston's out-of-school time program providers in engaging youth in quality hands-on science, technology, engineering, and mathematics practices;

- Integrate youth development skills with school and out-of-school time experiences in order to increase student interest and achievement in STEM subjects.

Measurement

- Identify and review measures of student interest, academic achievement, and program capacity (both in-school and out-of-school) in order to drive disparate and collaborative Network activities toward common goals.

In the fall of 2011, the community of stakeholders agreed that the first priority for our network was to establish a baseline against which we could evaluate our impact on students and families, educators, and industry. A second priority included cataloguing, describing, and analyzing the wide array of STEM opportunities available to Boston Public School students through district initiatives and through partnering with community-based, higher education, and industry providers.

The STEM Measurement Task Force, chaired by Dr. Kamal Chavda, Chief Data and Accountability Officer for the Boston Public Schools, began meeting in February 2012 to develop this report and to establish a series of system capacity and student outcome benchmarks for the network. While the state has established goals in areas extending beyond the K–12 system, the Measurement Task Force is starting by focusing its attention in this report on three subgroups of individuals — elementary, middle, and high school students.

SECTION II:

NETWORK DEVELOPMENT

Origins

In summer 2011, Massachusetts Education Secretary Paul Reville and Higher Education Commissioner Richard Freeland asked the Boston Private Industry Council (PIC) to organize the convening of the Commonwealth's Boston STEM Network. Co-chaired by Boston After School & Beyond, the United Way of Massachusetts Bay and Merrimack Valley, the Boston Public Schools, and the PIC, the Network is comprised of representatives from public education, STEM-related businesses, out-of-school program providers, philanthropic partners, and others from the community.

After meeting in October 2011 to explain the context and charge for the Boston STEM Network, participants in the network agreed that a first focus for the network should be increasing student interest and engagement.

Task Force Activites

The three task forces of the STEM Network conceive, develop, and implement the Network's plan. The Measurement Task Force has focused exclusively on developing this report to serve as a foundation for future efforts. The other two, Out-of-School Time and Career Awareness, have used the first year to address task force goals, chart priorities, and begin taking action toward increasing coordination.

The Out-of-School Time Task Force is co-chaired by Peg Sprague (Senior Vice President, Community Impact at United Way of Massachusetts Bay & Merrimack Valley) and Chris Smith (Executive Director, Boston After School & Beyond). Under their leadership, the task force sought ways to leverage the investments already made in the after-school sector and to amplify capacity to integrate STEM content and youth experiences after school and in the summer.

The primary vehicle for this work was professional development. The Informal Science Forum in April 2012 showcased innovative national and local approaches to hands-on science education and provided opportunities for sharing best practices amongst colleagues. Maryann Stimmer of the Educational Equity Center gave the keynote address entitled "A National Perspective on STEM Learning in After School Settings," and Lieutenant Governor Tim Murray, Chair of the Governor's STEM Advisory Council, spoke to the crowd of 130 field leaders. The event featured two panels on Policy and Practice and included representatives from the Noyce Foundation, Thompson Island Outward Bound Education Center, Boys & Girls Clubs of Boston, FastCAP Systems, Vertex Pharmaceuticals, Boston College, and Program in Education, Afterschool & Resiliency (PEAR) at Harvard University and McLean Hospital. In the summer, the task force organized two learning exchanges so that practitioners could see different approaches to summer learning strategies in the field. Guests were also invited to participate in and observe half-day sessions at MathPower at Northeastern University and at the Thompson Island Center.

The Career Awareness Task Force has come together this year to promote partnerships between middle schools and external resources and to spread awareness of STEM education and career pathways to families and students. Task force members have created and delivered engaging presentations for parents and families as part of Boston Public Schools' Parent University and they continue to conduct community outreach in more intimate settings.

SECTION III:

CURRENT INITIATIVES

The three task forces of the Boston STEM Network address qualitative goals of engaging with the community at-large and the community of educators in both formal and informal settings, as well as with the community of STEM professionals. Measuring progress in each of these areas will be assessed through the lens of the work of each task force — measurement, career awareness, and out-of-school time — and through strategic initiatives within the Boston Public Schools.

Community Engagement

State Standard

Every Massachusetts community will foster increased student interest in STEM through programming and spreading awareness. In order to spark and sustain student awareness of, interest in, and motivation to pursue advanced STEM education and related careers:

- In every community, parents, educators, employers, student leaders, and STEM professionals will be informed and enlisted as advocates to influence, support, and sustain student commitment to STEM from Pre-K through post-secondary education.
- Pre-K through 16 students will have access to rigorous academic and technical preparation in the STEM subjects and be encouraged to engage in experiential and applied learning opportunities.
- Collaboration is critical. Effective collaboration can enhance existing opportunities and bolster the development of systems at the community level to engage students at various points along the STEM pipeline — from preschool to career.

Boston Contribution to Assessing and Meeting the State Standard

The Career Awareness Task Force is actively seeking opportunities to share information about STEM careers and education pathways to success. In partnership with the Boston Public Schools, the PIC and partners from higher education are offering workshops at BPS Parent University sessions. The Out-of-School Time Task Force is quantifying STEM program capacity by asking after-school and out-of-school time programs to make increased use of Boston Navigator, an online database of youth programs. The task force is also working to develop more experiential and applied learning opportunities that complement youths' in-school experiences. Finally, the Measurement Task Force is developing a resource to hold the community accountable for supporting and sustaining student interest, achievement, and readiness for STEM opportunities.

Academic Coherence

State Standard

Massachusetts STEM standards, curriculum frameworks, instruction, and assessments will:

- Incorporate a balanced focus on deep content knowledge, mathematical and scientific inquiry, and problem solving/design, reflecting post-secondary faculty expectations for college and career readiness and employer expectations for STEM careers.
- Align vertically across grade levels and horizontally across subject strands to ensure coherent subject progressions among schools, across districts, and through college.
- Connect community-based experiential and project-focused learning resources to Pre-K through 12 curricula and/or through collaborative use of STEM-related laboratories in the vocational technical schools.

Boston Contribution to Assessing and Meeting the State Standard

Boston Public School (BPS) District's program departments have implemented a number of strategies to align and integrate new curriculum frameworks, instructional methodologies, and assessments in schools. The BPS Mathematics Office and Sciences Office are both active contributors in the development of new standards. Each of these departments works directly with the Massachusetts Department of Elementary and Secondary Education (MA DESE) and Achieve (a bipartisan non-profit organization that helps states raise academic standards, improve assessments, and strengthen accountability while leading efforts to develop the Next Generation Science Standards). Based on a deep understanding of these frameworks, system resources are aligned to support rigorous professional development for teachers as well as connections to resources in the community.

Mathematics

The Mathematics Office convened workgroups to study the new framework and identify curriculum materials that could be used to address new standards across grade levels. These groups produced comprehensive scope and sequence pacing guides for all grade levels in the Boston district. To follow up on the preparation for the transition to new standards, professional development will target the major shifts in content that have occurred from one grade level to the next, as well as targeting topics that teachers tend to struggle with.

The Math Office collaborates with the Urban Mathematics Leadership Network, the Dana Center, the Council of Great City Schools, Student Achievement Partners, and PARCC in order to access strategies, materials, and resources that support the district's transition to the 2011 Massachusetts Curriculum Frameworks (MCF).

The district also supports some resources either directly or through partnership to extend learning outside of the classroom. The BPS Department of Extended Learning Time, Afterschool, and Services (DELTAS) offers Math MCAS prep in a number of high schools. In partnership with colleges and universities in the city, some schools in the district allow students to take math courses for college credit and offer SAT and Advanced Placement test prep sessions and/or tutoring.

Science

Since the 2001 adoption of state science frameworks, the Boston Public Schools has focused on reform elements developed by the Center of Science, Mathematics and Engineering Education at the National Academies of Science. These reform elements include: a challenging curriculum for all students, materials management, and assessments aligned with curricula to address issues of academic coherence. In partnership with curriculum developers and university partners, the department established an articulated instructional sequence for all students in grades K–11, aligned with the Massachusetts Science and Technology/Engineering (MA STE) Framework. Instructional materials are refurbished and stored centrally and rotated throughout schools in the city. This innovation reduced costs and alleviated teacher responsibility for maintaining and purchasing materials. To support vertical articulation from one grade to the next, the department worked with K–12 teachers and university and community college faculty to identify and understand the conceptual "big ideas" across K–16, and to develop resources that support the implementation of a coherent, aligned instructional sequence. Assessments continue to be used to understand and drive instruction.

A strong cadre of teacher leaders is involved in the core work of the department to best meet the curriculum and instruction needs of science teachers across the district. These teachers are supported by the science department staff working with lead partners to develop their content knowledge and instructional skills, reflective practices, and leadership capacity. In addition to supporting teacher leader development, the work of the National Science Foundation (NSF) funded Boston Science Partnership has strengthened STE teaching through content courses, AP teacher and student support, and collaborative coaching cycles in schools across the district.

BPS Eighth Grade Algebra Expansion

The Boston Public Schools, in partnership with EdVestors, launched a special initiative to address the gaps in access and quality in eighth grade algebra in order to prepare more students for high school and college success. The goal of the initiative is to have 40% of eighth graders enroll in algebra by 2014 and earn passing grades, leading to ninth grade enrollment in a higher-level mathematics course such as Geometry or Algebra II. To accomplish this, the initiative is focusing on six strategies:

1. Improving eighth grade Algebra instruction;

2. Supporting students to achieve Algebra success;

3. Developing uniform criteria for student placement into eighth grade Algebra;

4. Successfully placing students in high school math courses;

5. Realigning the K–12 Math curriculum;

6. Focusing on data to track progress.

As the nation explores the Next Generation Science Standards, the department has been working with MA DESE and the broader science education community to contribute to the conversation and to prepare for the content and instructional shifts that will accompany the new Framework. Science teacher leaders have been working with the Science department to provide critical feedback to MA DESE and to Achieve with regard to the potential impact of new standards on teaching and learning science and engineering in the Boston Public Schools.

Educator Development

State Standard

Every student will learn from highly effective educators in every STEM subject area at every grade level, Pre-K through 16. Massachusetts educators will:

- Possess deep subject matter knowledge that spans grade levels; be skilled in the pedagogy of inquiry and problem solving; and be prepared to incorporate experiential and applied learning that integrates science, technology, engineering, and mathematics in coherent classroom instruction.
- Make effective use of technology as a tool for learning, recognizing its application as an essential resource for every 21st century STEM profession.
- Seek out innovative ways to further improve their understanding of their students' strengths and weaknesses, through data analysis and the creation of active assessments.

Boston Contribution to Assessing and Meeting the State Standard

Mathematics

In partnership with the MA DESE, BPS hosts monthly Mathematics Liaison Meetings for mathematics coordinators in the district, where they share strategies for strengthening math teaching and general learning, as well as discuss the transition to the new 2011 Massachusetts Curriculum Frameworks (MCF) for Mathematics. Through this partnership with MA DESE, the Mathematics department has been offering courses for teacher leaders, including a 30-hour Mathematics Learning Communities (MLC) course where teacher leaders are prepared to support the creation of math learning communities among teachers in their buildings, an 80-hour Massachusetts Intel Mathematics Initiative (MIMI) course designed to strengthen the mathematics content knowledge of K–8 teachers, and several 60-hour Developing Mathematical Practices courses. All of this professional development coursework is closely aligned with the 2011 MCF for Mathematics.

The Mathematics Department generates professional development for teachers through collaboration with a number of external partners such as TERC, Education Development Center (EDC), and higher education providers. Sometimes this entails bringing BPS staff together with curriculum material developers or academicians to learn best practices for integrating the materials and strategies into their classroom instruction. Boston also has a partnership with First in Math (FIM), an online program designed to build fluency with numbers and operations in grades 1–8. Staff from FIM work closely with BPS staff to set up student accounts, create systems for tracking student data, and provide professional development support that helps teachers see the alignment between this tool and the new 2011 MCF for Mathematics.

Finally, there is a strong relationship with the Boston Teacher Residency Program (BTR), which provides prospective teachers with a program of coursework and classroom-based experience that leads to teacher certification. The mathematics program office works closely with the faculty members who provide mathematics coursework for these prospective teachers, and they also work closely with BTR staff members who support these prospective teachers in their classroom placements. This helps ensure strong alignment around ambitious goals for mathematics instruction. A number of individual schools also have productive partnerships with local colleges and universities, including their pre-service teacher education programs.

TechBoston, a unit of the BPS Office of Instructional & Information Technology (OIIT), focuses on inspiring Boston Public School students by providing access to cutting edge technology resources and opportunities that advance their academic and career aspirations. The TechBoston staff carries out this mission on three levels: 1) structuring events to build technology awareness among younger students; 2) providing classroom materials, support, and teacher

professional development to improve teaching and learning; and 3) working with the Boston Private Industry Council to place technology-skilled high school students in jobs and internships.

Science

The National Science Foundation-funded Boston Science Partnership was an ambitious collaboration to raise student achievement through improved quality of BPS science teachers' instruction. It provided students with firm science conceptual frameworks to support their success in higher-level high school courses and postsecondary programs. While NSF funding is no longer supporting the partnership, the investment resulted in a number of lasting systemic structures that support teacher professional development, specifically: contextualized content courses, collaborative coaching and learning cycles, vertical team planning, and science fellowship. BPS teachers and university STEM faculty co-plan and co-teach summer content courses that deepen teachers' science content knowledge. These teachers are then eligible to participate in collaborative coaching and learning cycles during the school year, which gives them an opportunity to apply content knowledge gained during the summer and to also be part of a community of practitioners, reflecting on instructional techniques and assessment strategies. Teams of middle and high school teachers and STEM faculty focus on the content to plan vertical science curriculum. This kind of systemic collaboration has garnered results. Student enrollment in AP Science courses nearly quadrupled over a nine-year period. Further, regardless of race or economic status, more students passed the eighth grade MCAS if they had teachers who participated in Boston Science Partnership events.

The Science Department continues this work with UMass Boston, Northeastern University, and Roxbury Community College on the Boston Energy in Science Teaching grant, one of only seven NSF Phase II Math-Science Partnerships in the country. This project explores the impact and efficacy of teaching science with the crosscutting concept of energy — one of the seven crosscutting concepts currently included in drafts of the Next Generation Science Standards. Additional partnerships with Boston University, EDC, Boston College, the Museum of Science, Zoo New England, Harvard Medical School, the Concord Consortium, WestEd, the Exploratorium, and Lawrence Hall of Science strengthen the department's professional development opportunities for K–12 teachers. The department has begun to prepare for the transition to a new MA STE Framework, using research-based practices and processes, involving teachers and teacher leaders as well as the broader science, engineering, and education community.

STEM Employers and STEM Professionals

State Standard

Employers and the community of STEM professionals (from industry and education) can provide an array of opportunities for experiential learning, both inside and outside the classroom, by:

- Participating in educator professional development and communicating their expectations for students wishing to pursue a career in their sector. Employers and STEM professionals will serve as mentors, internship/co-op supervisors, leaders of community-based after-school and expanded learning time programs and partner with schools to offer new programming and expand existing programming such as the already state approved STEM programs in vocational schools.
- Sponsoring university laboratory research and industry-based teacher externships. They will also serve as collaborative partners in high quality professional development and pre-service programs.

Boston Contribution to Assessing and Meeting the State Standard

Dating as far back as the early 1980s, Boston's business community has recognized the value of investing in the city's young people. The Boston Private Industry Council serves as the school-to-career intermediary and partner to the Boston Public Schools, annually brokering and connecting thousands of young people to career-related experiences, including job shadows, mock interviews, and school-year and summer employment. Industry leaders open their offices, laboratories, and construction sites to young people as a way to stimulate STEM interest and promote career aspiration.

SECTION IV:

INFORMAL SCIENCE & SCHOOL PARTNERSHIPS

Out-of-School Time

Beyond academic measures, opportunities for STEM learning outside the classroom are an important component of raising the interest, engagement, and achievement levels of Boston students in STEM. While additional research is needed to make the link between informal science instruction and student interest and achievement, we do know that "average Americans spend less than 5 percent of their life in classroom," and that "most science is learned outside of school."[2] Given the substantial amount of time left to programming outside the classroom, the role of out-of-school time (OST) and informal science education is an important component of Boston's STEM strategy. In comparison to youth who did not participate in OST STEM activities, those who did participate were more likely to report a career interest in a STEM discipline in college.[3] In addition, connecting OST participation with school curriculum appears to enhance the educational effectiveness of these experiences for youth.

The current measure of out-of-school time STEM opportunities comes from Boston Navigator, Boston's comprehensive database of out-of-school time opportunities for youth. The database allows users to search for more than 1700 programs that run after school, before school, on weekends, during the summer, and during school vacations. Co-managed by Boston After School & Beyond and the City of Boston, Boston Navigator allows out-of-school time programs serving youth and young adults up to age 26 to publish profiles describing their program offerings. Profiles include information such as location, days offered, and content focus, to help families, youth, and community members find programs that fit their needs. Users can offer reviews and ratings of programs.

This analysis focuses on the information provided by programs which self-categorize as STEM programs on Boston Navigator. Since Boston Navigator profiles are completed and managed by programs, the information displayed is the programs' own characterization of their offering. To understand how representative this sample is of the greater population of STEM programs in the city, a comparison with the membership list from the Boston STEM Network reveals that 56% of known STEM programs are included in the Boston Navigator analysis.

Of more than 1700 programs listed on Boston Navigator, 88 classify themselves as STEM programs.[4] These programs are run by 40 different organizations, suggesting that on average, organizations run two types of STEM-related programs. Of these 88 programs, 42 run during the summer and 46 run during the academic-year.

Key observations:

- STEM programs are heavily concentrated in certain geographic areas in the city.
- Data is limited by how completely and accurately programs enter their program offerings into the system.
- There is a low student capacity reported by OST STEM programs in Boston compared to the number of students in Boston Public Schools.

Limitations of Analysis

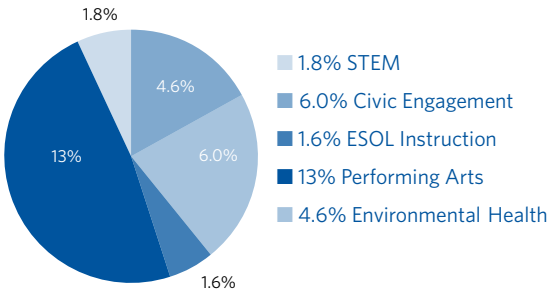
There are several limitations to the data available for this inventory. Inclusion in the analysis was based on a program's self-assignment as an Academic and STEM program in Boston Navigator. It is important to note that programs populate their own profiles, so profiles vary in completeness. Since data was limited to the information which programs included on their profile, data points were not consistent among programs. Based on the details that programs report in their Boston Navigator profiles, the following analysis provides a snapshot of STEM OST programming in Boston and a baseline against which to measure the improvement of future data collection and analysis. Better data collection and standardizing assessments would enhance analysis of STEM opportunities in the city.

Low Capacity of STEM Programs

STEM programs report an aggregate student capacity of 3644, out of the 57,000 students in Boston Public Schools. The program capacity amounts to 6.4% of BPS students. Even allowing for the fact that this analysis only includes about half of STEM programs in Boston, this is still a low capacity given the number

of BPS students. The following chart shows the capacity of STEM programs in comparison to other OST programming options, based on the total capacity of all STEM programs in Boston Navigator. The average maximum enrollment for programs is around 54 students, though most programs enroll closer to 30 students.

OST Capacity, as % of Total Capacity Reported on by Boston Navigator



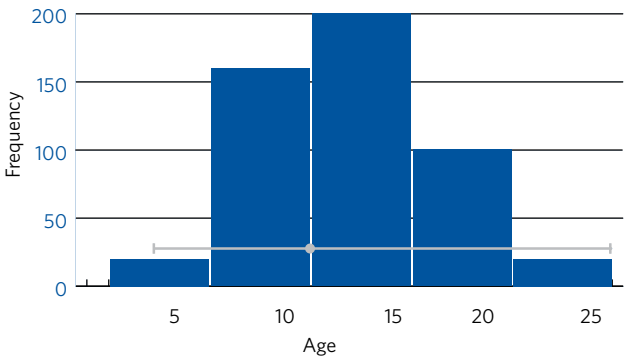
Uneven Geographic Spread of Programs

STEM programs take place across the city but do not evenly serve all neighborhoods. A majority of programs are based in the upper West and North Zones and there are far fewer in the lower East Zone. For example, the Grove Hall, Hyde Park, and Mattapan neighborhoods are particularly lacking in STEM programming, according to this analysis. STEM programming is fairly well represented in Jamaica Plain and near college campuses such as Northeastern University and the Colleges of the Fenway. It should be noted that some of the addresses listed by programs on their Boston Navigator profile may be the main office address and not the program location.[5]

STEM Programs Reach More Older Youth

Overall, STEM programs provide opportunities for a wide age range of Boston youth. The youngest age served is four, while the oldest is 26. The most targeted age is 11 years old and the average age served is 12, which locates most of the programming in the middle school population. Comparatively few programs work with high school youth or younger youth in elementary school.

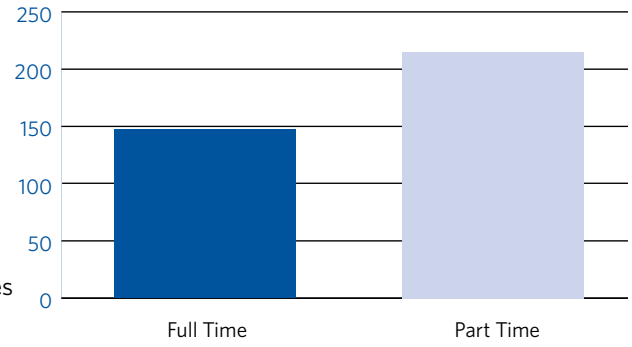
Distribution of Age of Youth Served



Staffing

STEM programs report far fewer full-time staff than part-time staff. While the response rate on staff size was only 57%, on average, programs reported seven full-time staff and ten part-time staff. Only 38% of programs recorded having part-time staff, meaning that many programs rely only on small staffs of full-time employees. The chart below provides a sense of the varying staffing structures of STEM programs.

STEM Programming Staffing Capacity, Total

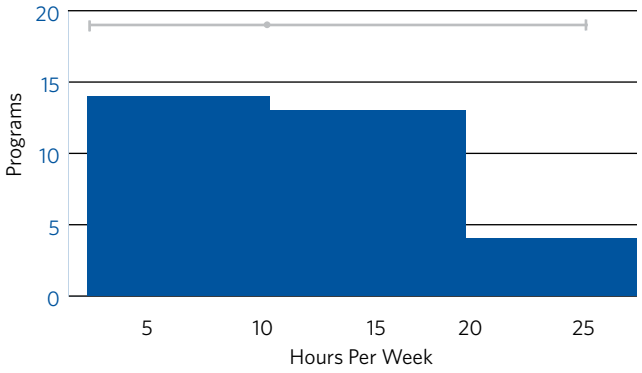


STEM Programs Available Year-Round

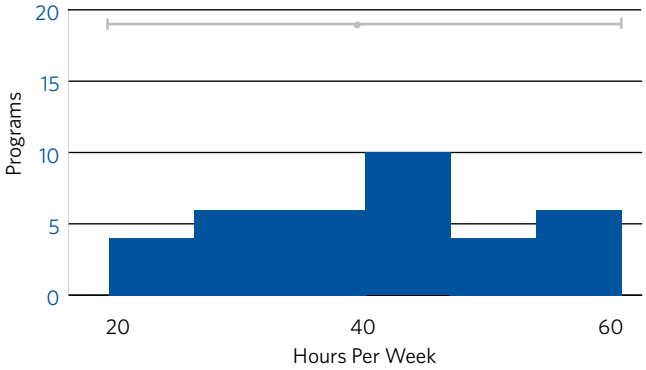
STEM programs provide an average of 20 hours per week in programming. Several full-day STEM summer programs exist and they skew this average, as most programs offer programming for just three hours a week. While on average, programs run for about 19 weeks, whether a program is summer or academic-year greatly affects the duration of the program. When looking at only summer programs, the average program runs for just under nine weeks and for 30 hours a week, capturing most of the summer vacation period. Academic-year programs run for an average

of 32 weeks, or about eight months, for 11.4 hours a week. Youth therefore have access to STEM programs for the entirety of the year, during the summer break and the academic year.

Distribution of Academic Year Program Hours



Distribution of Summer Programming Hours



STEM Jobs and Internships

Many young people aspire to work after school and during the summer. While the youth employment market has been hard hit in recent recessionary periods, the City of Boston and the Boston business community remain dedicated to providing summer jobs for the city's youth. During the 2012 Boston Summer Jobs Campaign, major healthcare providers and other industry leaders opened up their workplaces to students to "earn and learn." Many employers offer complementary programs and workshops that make summer student experiences a more comprehensive career/life learning opportunity. In the summer of 2012, nearly 575 students worked at 45 organizations including Massachusetts General Hospital, Brigham & Women's Hospital, Children's Hospital, Beth Israel Deaconess Medical Center, Dana Farber Cancer Institute, Fast Cap Systems, and Vertex Pharmaceuticals. Programs such as Youth Design and Boston Youth Environmental Network developed work sites at smaller employers that specifically linked to aspects of STEM careers. Of these students, 330 youth participated in targeted workshops as part of their jobs; these workshops addressed topics that included navigating the professional environment, career exploration, postsecondary and financial aid options, and healthy community/life choices.

Clean Energy Internship Program

The Boston Youth Environmental Network (BYEN) Clean Energy Internship Program was a six-week paid summer internship for 20 Boston youth. These interns gained hands-on experience working with clean energy companies four days a week and they learned about the science behind clean energy through weekly Friday field trips and sessions with "Roots of Success" held at the Benjamin Franklin Institute of Technology.

Summer 2012 Tech Apprentice Program

The Tech Apprentice Program was a seven-week internship opportunity provided by local companies across a diverse group of industries (including financial services, healthcare, non-profit, higher education, media, and information technology). These companies enrolled 122 technology-skilled high school sophomores, juniors, and seniors in the Boston area. Apprentices worked with a range of software programs such as Microsoft Visio and SharePoint and were able to test their skills in networking, web design, and Q&A testing. Students also provided support for helpdesk and web development teams as well as creating web services from backend databases.

For many young people, their first step toward a summer job begins with a job shadow. In February 2012, 736 students shadowed professionals at over 153 sites for a day as part of the Boston PIC's 18th annual job shadow day. Almost 60% of these opportunities were at places of business that work in STEM-related industries.

Employers also demonstrate their commitment to academic performance through programs such as Classroom at the Workplace, where students receive paid-release time to remediate and advance their skills.

Summer 2012 Classroom at the Workplace Math and Science

The PIC and the BPS partnered for the 13th consecutive year to provide Classroom at the Workplace (CWP) — MCAS Prep for 117 Boston high school students who previously failed an English Language Arts (ELA), Mathematics, and/or Science MCAS test. All students participated in 90 to 120 minutes of ELA, math, or biology instruction as part of a summer job for seven weeks in July and August of 2012. By combining academic preparation with employment, students came to view their education as a means to a viable career.

Conclusion

The data compiled on STEM programs in Boston show an array of programs available to youth throughout the year, but with opportunity to expand capacity by targeting younger youth and by looking to grow in the neighborhoods currently lacking STEM OST programming. The available programmatic information does not answer questions of youth engagement or interest in STEM programs. Additional measures and assessments are needed to answer such outcome-related questions.

SECTION V:

QUANTITATIVE MEASURES

Overview

The Commonwealth of Massachusetts has tasked each regional network with aligning its efforts in pursuit of shared goals for the state. Below is an explanation of each of the state's goals in greater detail, the tools provided by the state, and the additional resources that the Boston Network has identified to measure and track our progress in each area.

In developing this baseline-setting report, the Boston STEM Network is drawing upon the measurement and evaluation tools readily available to the school district. While there are limits to the usefulness of the tools for certain measures, utilizing the existing resources is instructive for understanding how the network could advocate for policy changes and resource development to further measure progress against the state goals. The network has begun this work of exploring new tools and further investigating student interest in STEM subjects through collaboration with Boston After School & Beyond and PEAR.

Quantitative Goals

Student Interest

State Standard

Increase interest in STEM college majors among college-going MA public school graduates by 35% by 2016 (from 25% in 2009).

- Increase interest among the underrepresented gender in fields with a gender-based gap in interest.
- Increase interest among underrepresented races/ethnicities in fields with a race/ethnicity-based gap in interest.
- Increase interest in fields where there are anticipated gaps in future employment (from industry growth and/or retirement of current employees).
- Increase interest in STEM fields at early ages (including preschool and elementary school) to assist in increasing student motivation to attain higher levels of STEM academic achievement/performance.

A 2011 study published in the ***Journal of Science Education*** by Robert H. Tai and Adam V. Maltese found that student interest and self-confidence in science and mathematics in high school are strongly associated with students continuing STEM studies through college, above and beyond enrollment and achievement factors.[6] Data gathered through the ACT's Educational Planning and Assessment System shows that interest in STEM is declining and most students are not adequately prepared to succeed in college-level coursework. The students most likely to major in STEM fields in college and persist to earn their degrees are those who develop interests in STEM careers through early career planning and who take challenging classes that prepare them for college-level science and mathematics coursework.[7]

The following excerpt from the literature review in the UMass Donahue Institute's recent report, "Increasing Student Interest in Science, Technology, Engineering, and Math (STEM): Massachusetts STEM Pipeline Fund Programs Using Promising Practices", elaborates on the impact of STEM interest.

> In April 2010, the Business Higher Education Forum (BHEF) published a working paper describing a "system dynamics model of the U.S. STEM Education system" developed by the Raytheon Company.[8] The model recognizes that to increase the number of individuals entering STEM majors in college for eventual employment in STEM fields, students must be both ***proficient*** and ***interested*** in STEM.
>
> It is important that students become interested in STEM before they enter high school so they will enroll in courses that can prepare them for STEM majors or careers. According to one study,[9] 94% of eighth graders make course-taking decisions related to preparing themselves for postsecondary education or a career. According to another[10] (1) science achievement correlates with attitudes toward science, and (2) positive perceptions of science are lower among older students than younger. In light of these studies, middle school students who do not consider a STEM major or career as a possible option, or at least maintain a positive orientation toward STEM subjects, may not enroll in the necessary high school coursework that would allow them to properly prepare for, or enter, those fields later on.

> So, middle and elementary school interest in STEM is important to students' becoming prepared for STEM majors, which, in turn, is important to students' following through in majoring in a STEM field. In addition, this study found that being interested in a quantitative major in tenth grade had a significant effect on whether females chose quantitative majors in college. Consequently, not only is it important that interest in STEM be developed early, but that it be sustained.[11]

Boston Contribution to Assessing and Meeting the State Standard

In Boston, the best way to measure interest in STEM has been through questionnaires and surveys given to Boston students at different grade levels. The National Assessment of Educational Progress (NAEP) student questionnaire results provide a reporting baseline of student interest in STEM for grades 4 and 8. For students in higher grades, the Senior Exit Survey reports their interest in STEM and also provides a breakdown of interest in different STEM postsecondary majors. Further, in the summer of 2012, the Boston STEM Network piloted the implementation of the PEAR Common Instrument to measure student interest at the beginning and end of summer experiences that related to science and mathematics. While each of these measures proves helpful in determining the interest level in STEM for Boston students, there are limitations to each of the tools that are outlined in the summary below. The NAEP assessment only surveys grade 4 and 8 students, while high school-age students received a survey only as seniors and/or if they were involved in a summer program that implemented the PEAR instrument. Implementing more tools to reach a broader array of students will be extremely helpful as we continue to measure interest level in STEM.

Given that the network identified Increasing Student Interest and Engagement in STEM Subjects as its primary focus area, the Measurement Task Force sought to identify a tool that could be easily implemented across programs and age groups. Dr. Gil Noam from Harvard University and McLean Hospital's PEAR shared a tool that had been developed for this purpose at the network's May 2012 meeting. After some discussion, network members agreed that we should, at minimum, pilot the tool over the summer before encouraging its broad adoption.

Three different organizations volunteered to participate in the network's summer pilot. Over 180 middle and high school-age students completed pre- and post-tests in this pilot. Overall, the pilot indicated a strong interest in science among participants. Those who started with lower pre-test scores were more likely to demonstrate increased interest. Through Boston After School & Beyond, the tool will be piloted in other programs throughout the 2012–2013 school year.

Increase STEM Achievement among Pre-K through 12 Students

State Standard

Increase the percentage of all students scoring Proficient or Advanced on the Mathematics and Science & Technology/Engineering MCAS assessments.

- Increase the percentage of all fifth grade and eighth grade students scoring Proficient or Advanced on the Mathematics and Science & Technology/Engineering MCAS assessments by 20 percentage points by 2016.
- Increase the percentage of all high school students scoring Proficient or Advanced on the Mathematics and Science & Technology/Engineering MCAS assessments by 10 percentage points by 2016.
- Reduce the achievement gaps of fifth grade, eighth grade, and high school students on the Mathematics and Science & Technology/Engineering MCAS assessments by 25% between 2010 and 2014, and another 25% between 2014 and 2016.

Boston Contribution to Assessing and Meeting the State Standard

To best measure student achievement in STEM, valuable data can be pulled from a variety of assessments in STEM-related subjects administered to Boston students through the last several years. Results from the 2009 NAEP Science assessment, 2011 NAEP Mathematics assessment, and the 2012 MCAS Science and Mathematics assessments all measure achievement in STEM at different grade levels.

NAEP Results (Science: 2009; Mathematics: 2011)

The National Assessment of Educational Progress (NAEP), also referred to as the Nation's Report Card, is the largest nationally-representative assessment of American students' knowledge and abilities. Schools and students are randomly selected to participate in NAEP as representatives of the district and the state. This random selection of schools that represent the demographic and geographic composition of the district and state allows NAEP to provide a common yardstick for measuring the progress of students' education across the country. While each state has its own unique assessment, NAEP asks the same questions in every state, making state and district comparisons possible. Because NAEP assesses a variety of subjects over a set time period, the most recent NAEP mathematics results available to Boston are from 2011 and the most recent NAEP Science results available are from 2009. The next NAEP mathematics assessment is scheduled for 2013 while the next NAEP Science assessment is scheduled for 2015.

MCAS Spring 2012 Results: Science and Mathematics

The Massachusetts Comprehensive Assessment System (MCAS) tests all public school students in Massachusetts, including students with disabilities and English Language Learner students. The tests measure performance based on the Massachusetts Curriculum Framework learning standards for English Language Arts, Mathematics, and Science. Results are reported for individual students, schools, and districts. In grade 10, students must pass the grade 10 tests in English Language Arts, Mathematics, and one of the four high school Science and Technology/ Engineering tests as one condition of eligibility for a high school diploma. The Massachusetts Department of Education assesses Science in grades 5, 8, and 10, while Mathematics is assessed in grades 3 through 8 and grade 10. The following chart outlines the score range and performance level for students on each MCAS assessment.

Performance Level	Score Range
Advanced	260–280
Proficient	240–258
Needs Improvement	220–238
Warning (Grades 3–8); Failing (High School)	200–218

In addition, the MCAS program is used to track, on a yearly basis, schools' and districts' progress toward the objective of cutting their students' proficiency gaps in half by 2017. Starting in the 2012–2013 school year, schools and districts will now be held accountable for how well their students are performing and improving on the MCAS Science assessment.

Increase the Percentage of Students who Demonstrate Readiness for College-Level Study in STEM Fields

State Standard

Increase the percentage of MA public high school students who report taking at least four years of Mathematics (from 69% in 2009) and three years of lab-based science (from 79% in 2009) to 100% in 2016, consistent with MassCore, as well as increase the percentage of MA public high school students who report taking advanced Mathematics (pre-Calculus and above) to 55% (from 44% in 2009) by 2016.

- Increase STEM course-taking among the underrepresented gender in courses with a gender-based gap in participation.
- Increase course-taking among underrepresented races/ethnicities in courses with a race/ethnicity-based gap in participation.

Boston Contribution to Assessing and Meeting the State Standard

While the state provides these data sets based on the student-reported SAT questionnaire, Boston is using course data directly from the city's information management system to determine how many high school students are on track to complete MassCore in Science and Mathematics. To complete MassCore in STEM subjects, students need to graduate from high school having enrolled in four mathematics courses and three science courses. Boston is also using AP course-taking and test scores as a measure of student readiness for college course work.

Increase the Number of Students who Graduate from a Postsecondary Institution with a Degree in a STEM Field

State Standard

Increase the number of students who complete STEM postsecondary degrees at MA public and private institutions by 50% from 2008 to 2016.

- Increase the number of Bachelor's degrees granted in all STEM majors to all students by 50% by 2016.
- Increase the number of Bachelor's degrees granted in all STEM majors to the underrepresented gender in majors with a gender-based gap in degrees.

Boston Contribution to Assessing and Meeting the State Standard

The National Student Clearinghouse allows Boston to track BPS graduates through college, assessing whether they have matriculated and completed post-secondary education as well as the college major conferred upon degree completion. These numbers are completed for both two– and four-year colleges/ universities.

SECTION VI:

ELEMENTARY SCHOOL STUDENTS

Curriculum

Listed below are the units and competencies for Boston Public Schools Science and Math elementary school curriculums.

Measure	Tool
Student Interest	NAEP
Student Achievement	MCAS, NAEP

Science

Grade	Unit/Course of Study			
K	Wood & Paper (FOSS)		Animals 2x2 (FOSS)	
1	Solids & Liquids (STC)	Organisms (STC)		Air & Weather (FOSS)
2	New Plants (FOSS)	Pebbles, Sand & Silt (FOSS)		Insects (FOSS)
3	Water (FOSS)	Sound (FOSS)		Structures of Life (FOSS)
4	Motion & Design (STC)	Magnetism & Electricity (FOSS)	Animal Studies (STC)	Rocks & Minerals (BPS Teachers)
5	Levers & Pulleys (FOSS)	Ecosystems (STC)	Landforms (FOSS)	Measuring Time (STC)
Grade 5 Science & Technology MCAS Exam				
Key	Structures of Life (FOSS)	Biology		Environmental

Mathematics

Key	Counting & Cardinality	Operations & Algebraic Thinking	Number & Operations: Base Ten	Measurement & Data	Geometry	Number & Operations: Fractions
K	Know number names & count the sequence Count to the number of objects Compare numbers	Understand addition as putting together & adding to, & understand subtraction as taking apart & taking from	Work with numbers 11–19 to gain foundations for place value	Describe & compare measurable attributes Classify objects & count the number of objects in each category	Identify & describe shapes Analyze, compare, create, & compose shapes	
1		Represent & solve problems involving addition & subtraction Understand & apply properties of operations & the relationship between addition & subtraction Add & subtract within 20 Work with addition & subtraction equations	Extend the counting sequence Understand place value Use place value understanding & properties of operations to add & subtract	Measure lengths indirectly & by iterating length units Tell & write time Represent & interpret data	Reason with shapes & their attributes	

Mathematics, continued

Key	Counting & Cardinality	Operations & Algebraic Thinking	Number & Operations: Base Ten	Measurement & Data	Geometry	Number & Operations: Fractions
2		Represent & solve problems involving addition & subtraction Add & subtract within 20 Work with equal groups of objects to gain foundations for multiplication	Understand place value Use place value understanding & properties of operations to add & subtract	Measure & estimate lengths in standards of units Relate addition & subtraction to length Work with time & money Represent & interpret data	Reason with shapes & their attributes	
3		Represent & solve problems involving multiplication & division Understand properties of multiplication & the relationship between multiplication & division Multiply & divide within 100 Solve problems involving the four operations, & identify & explain patterns in arithmetic	Use place value understanding & properties of operations to perform multi-digit arithmetic	Solve problems involving measurement & estimation of intervals of time, liquid, volumes, & masses of objects Represent & interpret data Geometric measurement: understand concepts of area & relate area to multiplication & to addition Geometric measurement: recognize perimeter as an attribute of plane figures & distinguish between linear & area measurements	Reason with shapes & their attributes	Develop understanding of fractions as numbers
4		Use the four operations with whole numbers to solve problems Gain familiarity with factors & multiples Generate & analyze patterns	Generate place value understanding for multi-digit whole numbers Use place value understanding & properties of operations to perform multi-digit arithmetic	Convert like measurement units within a given measurement system Represent & interpret data Geometric measurement: understand concepts of volume & relate volume to multiplication & addition	Graph points on the coordinate plane to solve real world & mathematical problems Classify two-dimensional figures into categories based on their properties	Use equivalent fractions as a strategy to add & subtract fractions Apply & extend previous understandings of multiplication & division to multiply & divide fractions
5		Write & interpret numerical expressions Analyze patterns & relationships	Understand the place value system Perform operations with multi-digit whole numbers & with decimals to hundredths	Convert like measurement units within a given measurement system Represent & interpret data Geometric measurement: understand concepts of volume & relate volume to multiplication & addition	Graph points on the coordinate plane to solve real world & mathematical problems Classify two-dimensional figures into categories based on their properties	Use equivalent fractions as a strategy to add & subtract fractions Apply & extend previous understand&ings of multiplication & division to multiply & divide fractions

Interest

A number of studies have shown that teacher support and enthusiasm, as perceived by students, demonstrably affects student interest in academics.[12] This is particularly true in younger grade levels; one study saw a significant drop in the strength of association between teacher support and student motivation in just two years.[13] Teacher enthusiasm for mathematics has been found to foster positive attitudes and excitement about mathematics in the classroom.[14]

Science

Utilizing the data available from the 2009 NAEP questionnaire, we find that fourth grade students are, for the most part, interested in and enthusiastic about science. In grade 4, students are asked the following questions on the Science assessment student questionnaire:

- How much do you like studying Science?
- How often do you feel that Science is one of your favorite subjects?

Overall, 60% of Boston fourth graders like studying science "quite a bit" or "very much," and 45% of Boston fourth graders feel that science is their favorite subject "often" or "always or almost always."

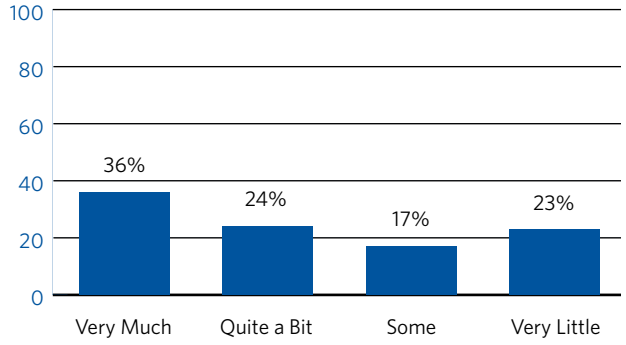
Mathematics

According to the data available from the 2011 NAEP questionnaire, fourth grade students find mathematics interesting. Students are asked the following questions on the questionnaire:

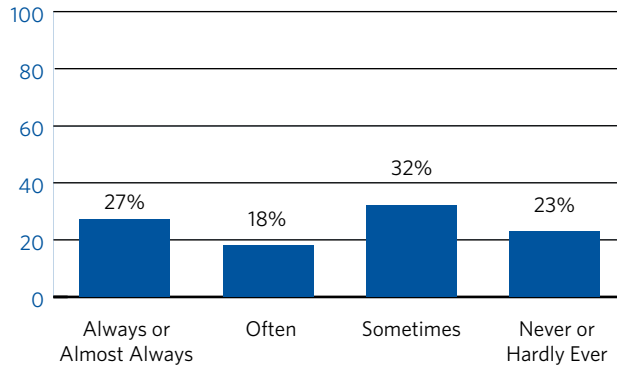
- How often do you feel you like Math?
- How often do you feel that Math is one of your favorite subjects?

Overall, 70% of Boston fourth graders feel that they like math "very much" or "quite a bit." 62% report that math is a favorite subject "often" or "almost always."

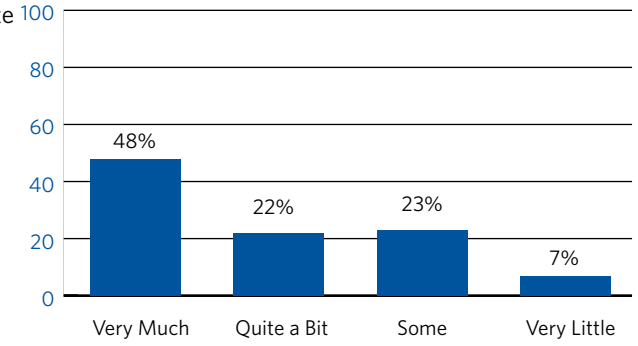
Grade 4: I Like Science (%)



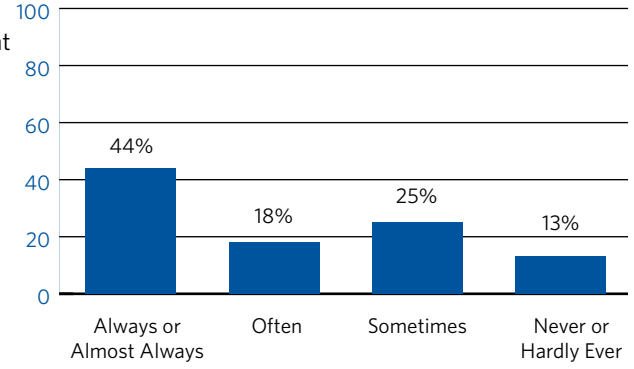
Grade 4: Science is a Favorite Subject (%)



Grade 4: I Like Math (%)



Grade 4: Math is a Favorite Subject (%)



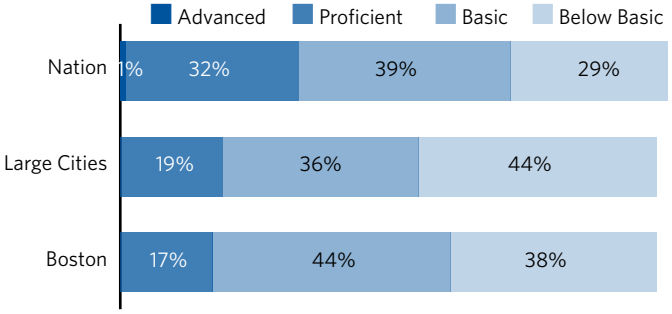
Achievement

There are four achievement levels that students can attain after completing the NAEP assessments. Based on their score, students will be placed in the "Advanced," "Proficient," "Basic," or "Below Basic" achievement level category. The charts following outline the percentage of students in each achievement level category for the nation, large cities, and Boston. Given Boston students' expressed level of interest, the low academic performance is glaring and suggests that there may be opportunities to leverage their interest in order to increase understanding and academic performance.

NAEP Science

As shown, 17% of Boston students scored at or above Proficient in 2009, compared to 33% nationwide and 19% in large cities. 38% of Boston's fourth graders scored at the Below Basic achievement level.

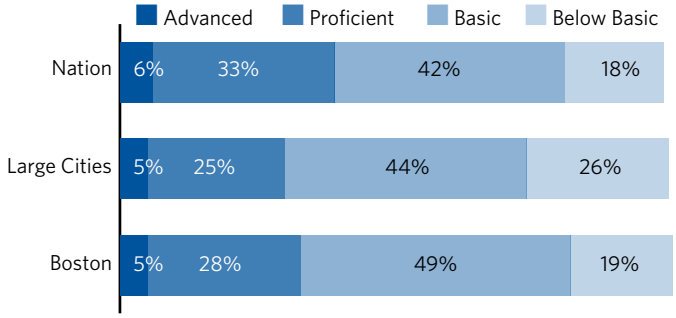
Grade 4 2009 NAEP: Achievement Level Results (%)



NAEP Mathematics

As shown, 33% of Boston students scored at or above Proficient in 2011, compared to 39% nationwide and 30% in large cities. 19% of Boston's fourth graders scored at the Below Basic achievement level.

Grade 4 2011 NAEP: Achievement Level Results (%)



MCAS Results: Science and Mathematics

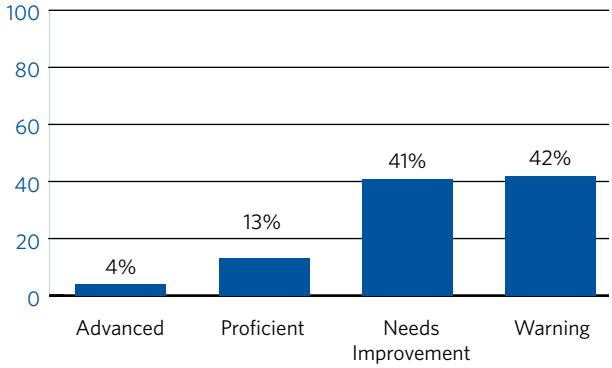
The MCAS Science assessment is given to Massachusetts students in fifth grade. This is the first data point that students receive from the state in the subject of science. Over the past two years, only 16–17% of Boston fifth graders have scored Proficient or Advanced on the grade 5 Science MCAS assessment.

Percentage of Boston Students Proficient or Advanced: Science and Technology/Engineering

	2008	2009	2010	2011	2012
Grade 5	17%	18%	21%	16%	17%

As shown in the following chart, most fifth grade students fell in the Needs Improvement or Warning category on their 2012 Science MCAS assessment.

2012 MCAS Science: Grade 5 (% of students)



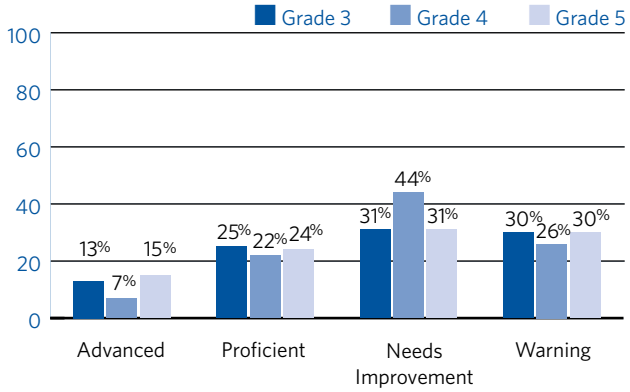
The MCAS Mathematics assessment is first given to Massachusetts students in third grade. In elementary school, the Mathematics assessment is administered to students in grades 3, 4, and 5. In the last two years, proficiency rates have declined for students in grades 3 and 5, while the percentage of students proficient or higher in grade 4 has remained constant at 29%.

Percentage of Boston Students Proficient or Advanced: Mathematics

	2008	2009	2010	2011	2012
Grade 3	36%	33%	42%	41%	38%
Grade 4	30%	27%	28%	29%	29%
Grade 5	33%	33%	39%	41%	39%

As shown below, most students in elementary school fell in the Needs Improvement or Warning category on their 2012 Mathematics MCAS assessment.

2012 MCAS Mathematics Grades 3, 4, 5 (% of students)



SECTION VII:

MIDDLE SCHOOL STUDENTS

Curriculum

Listed below are the units and competencies for Boston Public Schools Science and Math middle school curriculums.

Measure	Tool
Student Interest	NAEP
Student Achievement	MCAS, NAEP

Science

Grade	Unit/Course of Study		
6	Human Body Systems (STC)	Weather and Water (FOSS)	
7	Diversity of Life (FOSS)	Earth History (FOSS)	Forces and Motion (FOSS)
8	Planetary Science (FOSS)	Populations and Ecosystems (FOSS)	Chemical Interactions (FOSS)
Eighth Grade Science & Technology MCAS Exam			
Key	Physics & Chemistry	Biology	Environmental

Mathematics

Grades	Ratios & Proportional Relationships	The Number System	Expressions & Equations	Statistics & Probability	Geometry	Functions
6	Understand ratio concepts & use ratio reasoning to solve problems	Apply & extend previous understandings of multiplication & division to divide fractions by fractions Compute fluently with multi-digit numbers & find common factors & multiples Apply & extend previous understandings of the system of rational numbers	Apply & extend previous understandings of arithmetic to algebraic expressions Reason about & solve one-variable equations & inequalities Represent & analyze quantitative relationships between dependent & independent variables		Solve real work & mathematical problems involving area, surface area, and volume	Develop understanding of statistical variability Summarize & describe distributions
7	Analyze proportional relationships & use them to solve real world & mathematical problems	Apply & extend previous understandings of operations with fractions to add, subtract, multiply & divide rational numbers	Use properties of operations to generate equivalent expressions Solve real life & mathematical problems using numerical and algebraic expressions and equations		Draw, construct, & describe geometrical figures & the relationships between them Solve real life & mathematical problems, involving angle measure, area, surface area, & volume	
8	Investigate patterns of association in bivariate data	Know that there are numbers that are not rational, & approximate them by rational numbers	Work with radicals & integer exponents Understand the connections between proportional relationships, lines, & linear equations Analyze & solve linear equations & pairs of simultaneous linear equations		Understand congruence & similarity using physical models, transparencies, or geometry software Understand & apply the Pythagorean Theorem. Solve real world mathematical problems involving volume of cylinders, cones	Define, evaluate, & compare functions Use functions to model relationships between quantities

Interest

Science and Mathematics

On the 2009 grade 8 NAEP questionnaire, students were asked about their feelings on math and science, using the following statements:

- I like Science.
- Science is one of my favorite subjects.
- I like Math.
- Math is one of my favorite subjects.

Overall, student interest in math and science, as measured by the NAEP questionnaire, was high. More than 60% of Boston eighth graders agreed or strongly agreed with the statements "I like Science" and "I like Math," and more than 40% reported that math or science was a favorite subject. Please see graphs provided below for a detailed breakdown of student responses.

Achievement

Much like at the fourth grade level, eighth graders will be placed in the "Advanced," "Proficient," "Basic," or "Below Basic" achievement level category based on their NAEP assessment score. The following chart outlines the percentage of students in each achievement level category for the nation, large cities, and Boston.

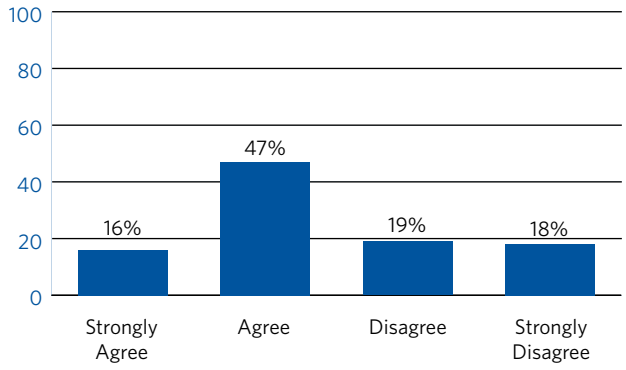
NAEP Science

In grade 8, only 14% of students scored at or above Proficient on the 2009 Science assessment, compared to 29% nationwide and 17% in large cities. 61% of Boston's eighth graders scored at the "Below Basic" achievement level.

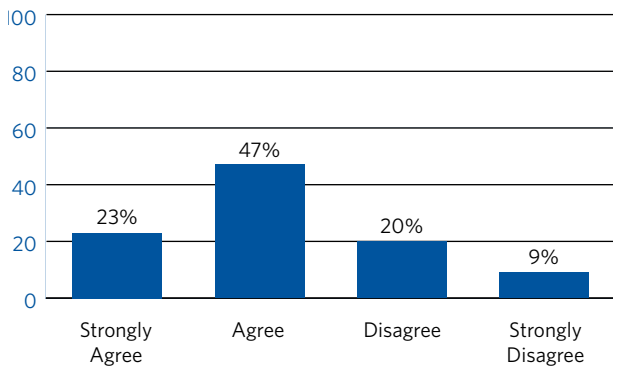
NAEP Mathematics

33% of Boston students scored at or above Proficient in 2011, compared to 34% nationwide and 26% in large cities. 31% percent of Boston's eighth graders scored at the "Below Basic" achievement level.

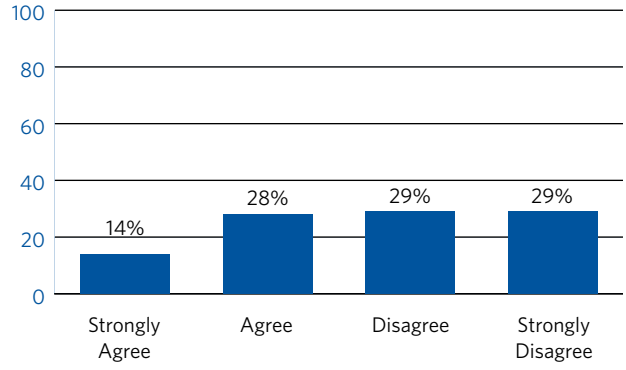
Grade 8: I Like Science (%)



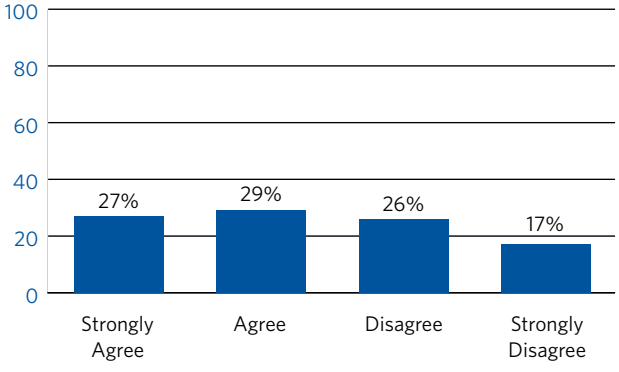
Grade 8: I like Math (%)



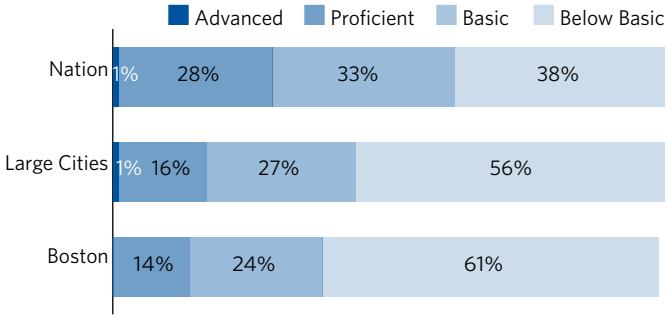
Grade 8: Science is a Favorite Subject (%)



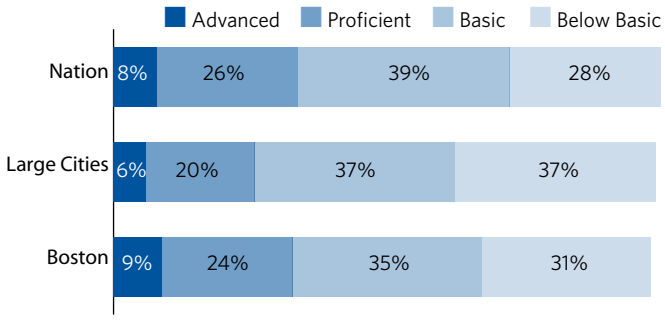
Grade 8: Math is a Favorite Subject (%)



Grade 8 2009 NAEP: Achievement Level Results (%)



Grade 8 2011 NAEP: Achievement Level Results (%)



MCAS Results: Science and Mathematics

In middle school, students are given the MCAS Science assessment in eighth grade. In grade 8, only 10% of students scored in the Proficient or Advanced level on their MCAS Science assessment from 2008–2011; in 2012, that number increased to 15%.

Percentage of Boston Students Proficient or Advanced: Science and Technology/Engineering

	2008	2009	2010	2011	2012
Grade 8	10%	10%	10%	10%	15%

As shown in the preceding charts, most students in eighth grade fell in the Needs Improvement or Warning category on their 2012 Science MCAS assessment.

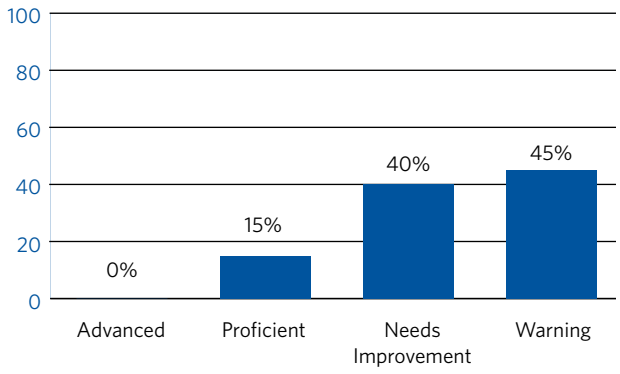
In middle school, the Mathematics assessment is administered to students in grades 6, 7, and 8. In the last two years, proficiency rates have increased for students in grades 6, 7, and 8.

Percentage of Boston Students Proficient or Advanced: Mathematics

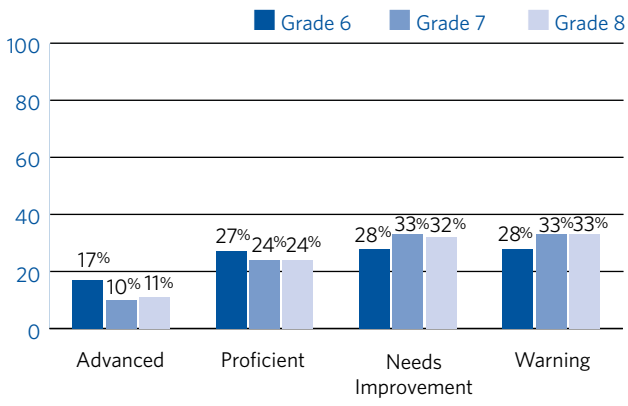
	2008	2009	2010	2011	2012
Grade 6	32%	33%	38%	36%	44%
Grade 7	28%	28%	37%	33%	34%
Grade 8	34%	28%	34%	34%	35%

Most students in middle school fell into the Needs Improvement or Warning category on their 2012 Mathematics MCAS assessment; however, a larger percentage of students are scoring in the Advanced and Proficient range than seen in earlier grade levels.

2012 MCAS Science: Grade 8 (% of students)



2012 MCAS Mathematics Grades 6, 7, 8 (% of students)



SECTION VIII:

HIGH SCHOOL STUDENTS

Curriculum

Listed below are the units and competencies for Boston Public Schools Science and Math high school curriculums.

Measure	Tool
Student Interest	Senior Exit Survey NSC (BPS College Graduates)
Student Achievement	MCAS — Science/Math
Student Readiness	AP Enrollment/Achievement MassCore

Science

9th grade	Active Physics		MCAS offered — grades 9 or 10	
9th or 10th	Biology: A Human Approach		MCAS offered — grades 9 or 10	
9th or 10th	Technology/Engineering		MCAS offered — grades 9 or 10	
10th or 11th	Living by Chemistry		MCAS offered — grades 10 or 11	
11th or 12th	AP Biology	AP Physics	AP Chemistry	AP Environmental Science

Mathematics

Number & Quantity	Algebra	Functions	Geometry	Statistics & Probability
The Real Number System Quantities Complex Numbers Vector & Matrix Quantities	Seeing Structure in Expressions Arithmetic with Polynomials & Rational Expressions Creating Equations Reasoning with Equations & Inequalities	Interpreting Functions Building Functions Linear, Quadratic, & Exponential Models Trigonometric Functions	Congruence Similarity, Right Triangles, & Trigonometry Circles Expressing Geometric Properties with Equations Geometric Measure & Dimension Modeling with Geometry	Interpreting Categorical & Quantitative Data Making Inferences & Justifying Conclusions Conditional Probability & the Rules of Probability Using Probability to Make Decisions

Interest

The Senior Exit Survey and the National Student Clearinghouse data files can be used to measure student interest in STEM. In both these analyses, students' interest (Senior Exit Survey) and students' postsecondary degrees (National Student Clearinghouse) were categorized into one of 33 different college majors as classified by the College Board.

College Major Classifications — College Board	
Agriculture Sciences	Mathematics and Statistics
Architecture	Military Technology/ Science
Area/Ethnic/Cultural Studies	Multi-Interdisciplinary
Biological Sciences	Natural Resources
Business Management	Parks/Leisure/Fitness
Communication & Journalism	Personal & Culinary Service
Computer/Information Science	Philosophy/Religious Studies
Education	Physical Sciences
Engineering	Psychology
Engineering Technologies	Social Service Professions
English Language/Literature	Security/Protective Service
Family/Consumer Science	Social Sciences
Foreign Languages	Theology/Religious Vocation
Health Professions/Sciences	Visual & Performing Arts
History	Other
Legal Professions & Studies	Undecided
Liberal Arts & Humanities	

Of the 33 possible major classifications, the following were categorized as STEM fields for the purpose of this report.

College Major Classifications — STEM
Architecture
Biological Sciences
Business Management[15]
Computer/Informational Science
Engineering
Engineering Technologies
Health Professions and Studies
Mathematics and Statistics
Natural Resources
Parks/Leisure/Fitness
Physical Science
Psychology

The Commonwealth's STEM Pipeline Fund-supported research provided by the Donahue Institute looks at student-stated preferences on the SAT questionnaire. In that analysis, only the following majors were included as STEM majors:

STEM Majors Included on SAT Questionaire
Agriculture & Natural Resources
Computer & Information Sciences
Mathematics & Statistics
Architecture
Engineering
Technology/Technicians
Physical Sciences
Biological & Biomedical Sciences
Health Professions & Clinical Sciences
Science Technology/Technicians

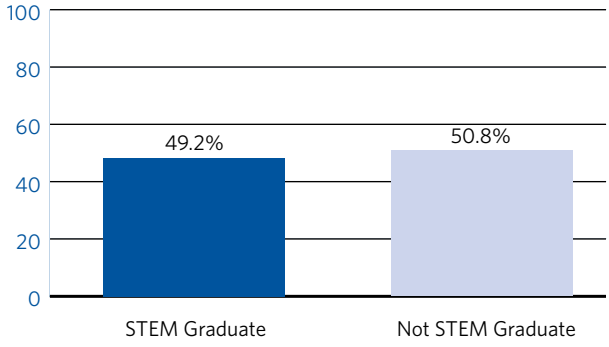
National Student Clearinghouse

Data from the National Student Clearinghouse (NSC) enables BPS to track students after they graduate from the district. This data source not only allows BPS to analyze whether its graduates attend college, but also provides BPS with information on college graduation and college degrees. All BPS graduates who matriculated and graduated with a major from a two- or four-year college in the years 2005-2011 (2229 students) are included in this analysis.

Of the 2229 students who graduated from Boston Public Schools and from a two- or four-year college, 49.2% (1098 students) graduated with a postsecondary degree that can be classified as STEM.

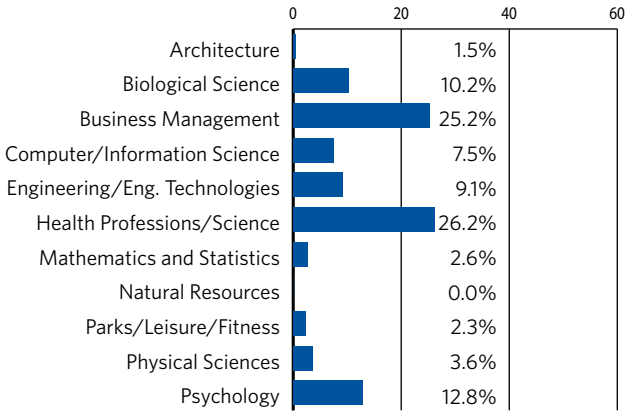
College majors listed in the National Student Clearinghouse file were grouped into the 33 College Board categories and classified as STEM or Not STEM. The tables to the right outline the number and percentages of students in the NSC file who obtained a postsecondary degree in a field that can be classified as STEM.

Percentage of BPS College Graduates (2005-2011) STEM Classification



College Majors	Number
Architecture	6
Biological Sciences	112
Business Management	277
Computer/Informational Science	82
Engineering/Engineering Technologies	100
Health Professions and Studies	288
Mathematics and Statistics	28
Natural Resources	0
Parks/Leisure/Fitness	25
Physical Science	40
Psychology	140
Total	**1098**

Percent BPS College Graduates (2005-2011) with STEM College Major



As shown, a large percentage of BPS students who recently graduated from a postsecondary institution are likely to enter into the field of Health Professions and Studies. The following chart suggests that, in the Health field, most of these students are obtaining degrees in Nursing or Medical Assisting.

NSC Health Professions Breakdown	Number
Nursing/Nurse Education	76
Medical/Dental Assistant	87
Health Sciences	19
Pharmacy	15
Pre-Med	9
Public Health	7
Nutrition	6
Radiology	3
Other	66
Total	**288**

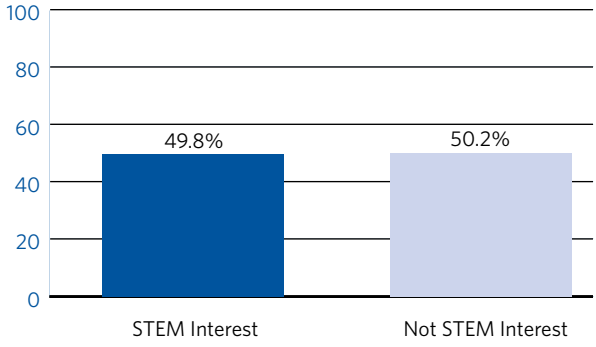
Senior Exit Survey

The BPS Senior Exit Survey assesses various domains of students' experiences in BPS, including school climate, family educational and employment backgrounds, instructional quality, high school experiences, and postsecondary education intentions. The BPS Senior Exit Survey has the ability to collect information for the majority of seniors in the system. In school year 2011–2012 (SY2011-12), 73% of Boston's senior class completed the Senior Exit Survey.

To measure student interest in STEM college and career plans through the Senior Exit Survey, students are asked, "If you are planning to attend college in the fall, what major field of study are you planning to pursue?" Of the 2137 students who answered the question, 49.8% (1064) of BPS seniors responded with a college major interest in the STEM field.

College major interests listed in the Senior Exit Survey were grouped into the 33 College Board categories and classified as STEM or Not STEM. The following charts outline the number and percentages of BPS seniors in SY2011-12 who were interested in a postsecondary STEM major.

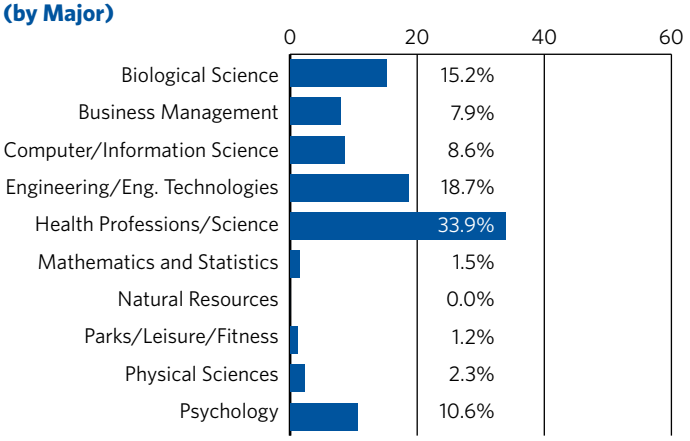
Percentage of BPS Seniors (2012) with College/ Career STEM Interest (Total)



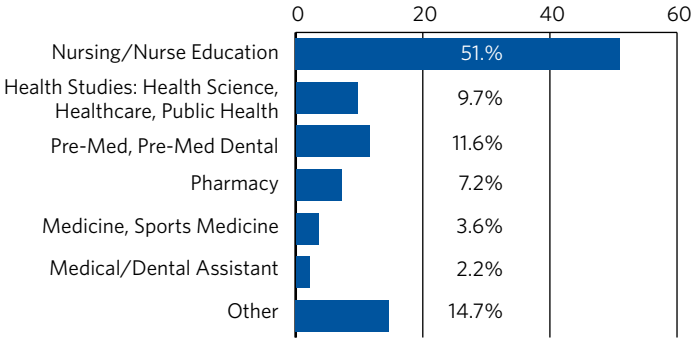
College Majors	Number
Biological Sciences	162
Business Management	84
Computer/Information Science	91
Engineering/Engineering Technologies	199
Health Professions/Sciences	361
Mathematics & Statistics	16
Natural Resources	0
Parks/Leisure/Fitness	13
Physical Sciences	25
Psychology	113
Total	**1064**

As demonstrated, a high percentage of BPS seniors from SY2011–12 were interested in the field of Health Professions/Science. The following chart suggests that, in the Health field, more than 50% of these students showed an interest in Nursing.

Percent BPS Seniors (2012) with STEM College/Career Interest (by Major)



Percent BPS Seniors (2012) with Interest in Healthcare Profession



Achievement

MCAS Results

In high school, students are given the MCAS Science assessment in tenth grade. Over the past year, students in grade 10 have shown an increase of seven points in the percentage of students scoring Proficient or Advanced on one of the four MCAS Science assessments.

Percentage of Boston Students Proficient or Advanced: Science and Technology/Engineering

	2008	2009	2010	2011	2012
Grade 10	29%	34%	36%	39%	46%

As shown below, most students in tenth grade fell in the Needs Improvement or Proficient level on their 2012 Science MCAS assessment.

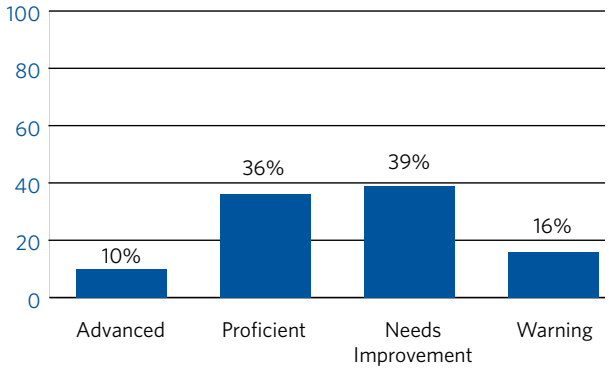
In high school, the Mathematics assessment is administered to students in grade 10. In the last year, proficiency rates have increased by three percentage points.

Percentage of Boston Students Proficient or Advanced: Mathematics

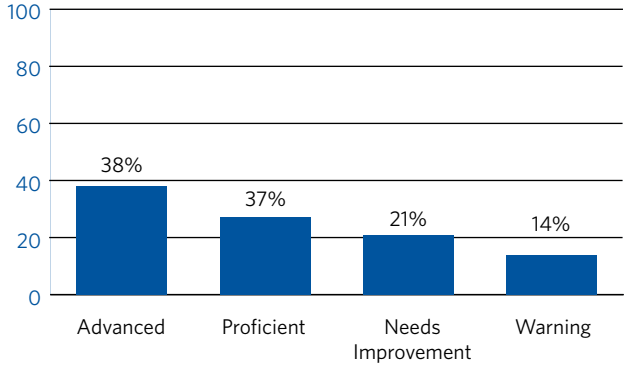
	2008	2009	2010	2011	2012
Grade 10	59%	62%	60%	62%	65%

As shown below, most students in high school scored in the Proficient or Advanced category on their 2012 Mathematics MCAS assessment.

2012 MCAS Science: Grade 10 (% of students)



2012 MCAS Mathematics: Grade 10 (% of students)



Student Readiness

A study done at Bunker Hill Community College, which consistently enrolls a large number of Boston Public School students, found that 88% of their incoming students in 2009 were placed into a developmental or remedial math course based on an entrance exam. The Network has created two measures to analyze whether students are prepared for college- and career-level STEM work.

MassCore

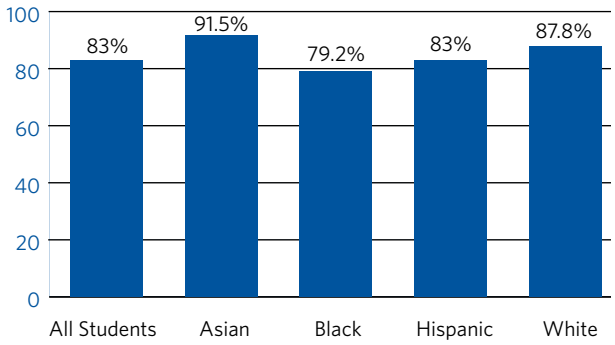
The Massachusetts High School Program of Studies (MassCore) is intended to leave Massachusetts graduates well-prepared for arrival at college or the workplace. Adopted in 2007, the MassCore program recommends that high school students enroll in four years of English, four years of mathematics, three years of a lab-based science, three years of history, two years of the same foreign language, one year of an arts program, and five additional core courses such as business, education, health, and/or technology.

This report focuses on the mathematics and science course-taking patterns of BPS students. Of particular interest is the cohort of eleventh grade students who have been continuously enrolled in the district since entering high school (82% of eleventh grade students in SY2011–12). Examining this cohort's course enrollment and success patterns serves as an early indicator of the proportion of students who are on-track to meet the MassCore requirements in the STEM subjects. To be considered on-track by the end of eleventh grade, students are expected to have completed at least three mathematics and two science MassCore-approved courses.

As a baseline measure, this report looks at the eleventh grade cohort in SY2011–12 that had been continuously enrolled in BPS high schools since SY2009–10.[16] Of the 3374 students in this group, 83% had met the minimum MassCore requirements for Mathematics and Science.

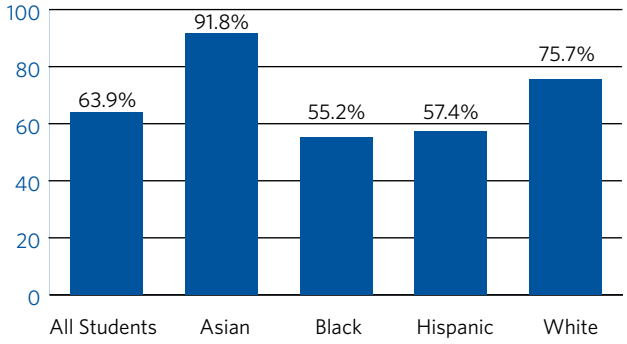
While more than 80% of eleventh graders pursue the MassCore program of studies, additional analyses show that only 64% received a final grade of D or better across all five courses. There are also substantial differences across student groups by race; only 55–57% of continuously-enrolled Black and Hispanic students received grades of D or higher in all five courses, in comparison to 76% of White students and 92% of Asian students.

Percentage of 11th Grade Cohort (2012) on Track to Meet MassCore in STEM Subjects



*Only subgroups with >30 students were reported in subgroup breakdown. "All Students" includes those students in smaller subgroups.

Percentage of 11th Grade Cohort (2012) with a Grade of D or Higher in all 5 MassCore STEM Courses (% of Subgroup)



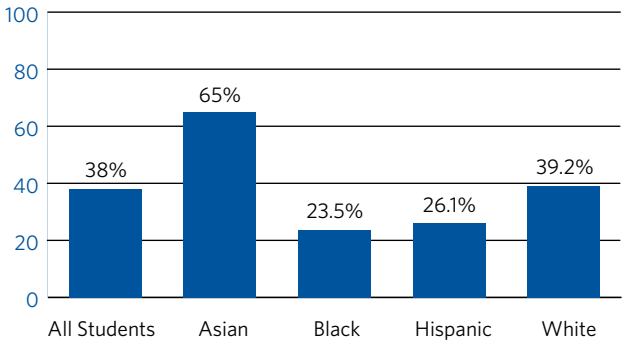
*Only subgroups with >30 students were reported in subgroup breakdown. "All Students" includes those students in smaller subgroups.

Added analysis shows that these numbers continue to drop. Only 38% of eleventh graders in the group of students on-track to obtain MassCore in STEM received a final course grade of C or better across all five courses. The disparities between race groups persist as a higher percentage of Asian and White students received higher marking grades.

The following chart outlines the percentage of students in the eleventh grade cohort who received a failing course grade (D- or lower) in any of the MassCore STEM subjects. While these students are on track to complete the MassCore requirement

in STEM, at least 20% of those students are failing Mathematics and Science at some point in eleventh grade. Course failures for this cohort of students continue to increase as they move from ninth through eleventh grade.

Percentage of 11th Grade Cohort (2012) with a Grade of C or Higher in all 5 MassCore STEM Courses (% of Subgroup)



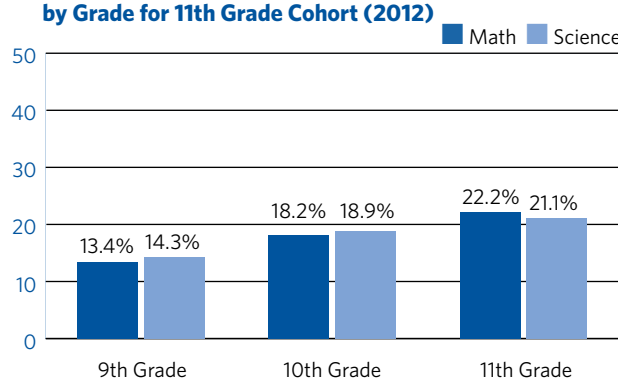
*Only subgroups with >30 students were reported in subgroup breakdown. "All Students" includes those students in smaller subgroups.

AP Enrollment 2011–2012 — Grades 11 and 12

There has been a steady increase in the number of Boston's eleventh and twelfth graders taking Advanced Placement (AP) courses between 2004–2005 and 2011–2012. In SY2011–12, 2474 students in grades 11 and 12 were enrolled in at least one AP course, compared to 2363 students in SY2011 and 2304 students in SY2009–10. Similarly, the number of AP courses offered in the district has also increased consistently. In SY2011–12, there were 147 AP courses offered to BPS students in a variety of subjects.

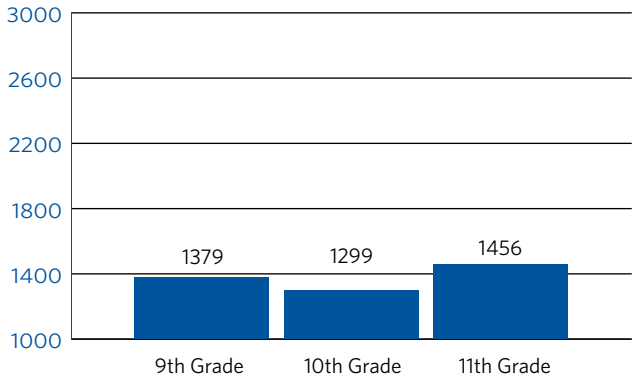
In the 2012 school year, Boston students took a variety of AP tests in STEM subjects ranging from Biology to Computer Science. Depending on the college/university, students can receive college credit for AP courses taken in high school if they receive a score of 3 or higher on their AP exam. In 2012, approximately 40% of all STEM test takers scored a 3 or higher on their AP test.

Percent of MassCore Math or Science Course Failures by Grade for 11th Grade Cohort (2012)



*Course Failures: D-, F+, F, F-

Number of 11th and 12th Graders Enrolled in any STEM AP Course (SY2009–10 — SY2011–12)



Percentage of BPS Students Obtaining a 3 or Higher on their AP Test 2012

Subject Test	Average Score	Score of 3, 4, or 5	All Test Takers	Percent Scoring 3 or Higher
AP Science	2.83	299	731	40.9%
AP Mathematics	2.76	252	621	40.6%
AP Technology/Engineering	2	38	122	31.1%

NOTES

[1] The National Assessment of Educational Progress (NAEP) is the only nationally representative, continuing evaluation of the condition of education in the United States. It has served as a national yardstick of student achievement since 1969. Through the Nation's Report Card, NAEP informs the public about what American students know and can do in various subject areas and compares achievement between states, large urban districts, and various student demographic groups.

The National Assessment Governing Board is an independent bipartisan board whose members include governors, state legislators, local and state school officials, educators, business representatives, and members of the general public. Congress created the 26-member Governing Board in 1988 to oversee and set policy for NAEP. NAEP is a congressionally-authorized project sponsored by the U.S. Department of Education.

The National Center for Education Statistics, within the Institute of Education Sciences, administers NAEP. The Commissioner of Education Statistics is responsible by law for carrying out the NAEP project.

[2] Falk and Dierking (2010) cited in Friedman, Alan J. and Ellen F. Mappen. "SENCER-ISE: Establishing Connections between Formal and Informal Science Educators to Advance STEM Learning through Civic Engagement." *Science Education & Civic Engagement: An International Journal* (Summer 2011).

[3] "Dadney, Katherine, et al. "Out-of-School Time Science Activities and Their Association with Career Interest in STEM." *International Journal of Science Education, Part B: Communication and Public Engagement* 2.1 (2012): 63–79.

[4] Numbers accurate as of June 27, 2012.

[5] In order to mitigate this concern, direct outreach was performed to programs with addresses that appeared to be a main office instead of a programming location

[6] Maltese, Adam and Robert Tai. "Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students." *Science Education* 95.5 (1993): 877–907.

[7] ACT, Inc. "Developing the STEM Educational Pipeline." *ACT website*. 2006. Web. 10 Feb. 2013. <http://www.act.org/research/Policymakers/pdf/ACT_STEM_PolicyRpt.pdf>

[8] Business Higher Education Forum. "Increasing the Number of STEM Graduates: Insights from the U.S. STEM Education and Modeling Project." *Business Higher Education Forum website*. April 2010. Web. Feb. 2013. <http://www.bhef.com/solutions/documents/BHEF STEM_Report.pdf>

[9] Akos, Patrick, et al. "Early Adolescents' Aspirations and Academic Tracking: An Exploratory Investigation." *Professional School Counseling* 11.1 (2007): 57–64.

[10] Neathery, M. Faye. "Elementary and Secondary Students' Perceptions toward Science and the Correlation with Gender, Ethnicity, Ability, Grade, and Science Achievement," *Electronic Journal of Science Education* 2.1 (1997).

[11] UMass Donahue Institute Research & Evaluation Group. "Increasing Student Interest in Science, Technology, Engineering, and Math (STEM): Massachusetts STEM Pipeline Fund Programs Using Promising Practices." *Massachusetts Department of Higher Education website.* March 2011. Web. 10 Feb. 2013. <http://www.mass.edu/forinstitutions/prek16/documents/Student%20Interest%20Summary%20Report.pdf>

[12] Breen, Michael J. "Teacher Interest and Student Attitude toward Four Areas of Elementary School Curriculum." *Education* 100.1 (1979): 63–66.

[12] Daniels, Erika. "Creating Motivating Learning Environments: Teachers Matter." *Middle School Journal* 42.2 (2011): 32–37.

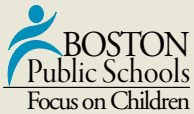
[13] Goodenow, Carol. "Classroom Belonging Among Early Adolescent Students: Relationships to Motivation and Achievement." *The Journal of Early Adolescence* 13.1 (1993): 21–43.

[14] Vaughn, Christy H. "Middle School Mathematics Students' Perspectives on the Study of Mathematics." Dissertation, Walden University (2012).

[15] Majors included: Finance; Economics; Accounting, Taxation; Business Finance. Does not include Marketing; General Business; Management; Sports Management.

[16] This cohort of students completed eleventh grade by June 2012. This cohort does not include students who may have taken summer school to complete their eleventh grade requirements.

Prepared by:



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