BOSTON SCIENCE PARTNERSHIP

Funded by the National Science Foundation

Summative Evaluation Report

2004—2009

EXECUTIVE SUMMARY

Written by:
Joan Karp, Senior Research Associate
Samara Hoyer-Winfield, Research Associate
Elizabeth Osche, Research Associate

Program Evaluation and Research Group
Debra Smith, Director

April 2010

PROGRAM EVALUATION AND RESEARCH GROUP
AT LESLEY UNIVERSITY

Boston Science Partnership

Summative Evaluation Report
Executive Summary

Program Evaluation and Research Group
Lesley University
29 Everett St.
Cambridge, MA 02138-2790

(617) 349-8172
perg@lesley.edu

www.lesley.edu/perg.htm

CONTENTS

EXECUTIVE SUMMARY
BOSTON SCIENCE PARTNERSHIP EVALUATION

INTRODUCTION

The Boston Science Partnership has enjoyed a successful 5 years with many important accomplishments. It has played a valuable role at each of its partner institutions, and for the individuals and groups that have participated in it and been most directly affected by it. This executive summary and the evaluation reports it summarizes tell part of the story of what was tried, what was learned, and what was gained during that time.

PROJECT DESCRIPTION

The Boston Science Partnership (BSP) was funded by the National Science Foundation (NSF) targeted Math and Science Partnership (MSP) program. Started in 2004, it is a collaboration between the core partners of the Boston Pubic Schools (BPS), the University of Massachusetts Boston (UMB), and Northeastern University (NEU). Harvard Medical School, Roxbury Community College, and the College Board have also been involved in the project as supporting partners. The Education Development Center (EDC) has investigated key research questions about the project as a supporting partner, and a UMB team has also conducted research related to BSP. SageFox Associates has evaluated student STEM pipeline activities and outcomes. The Program Evaluation and Research Group (PERG) at Lesley University has been the primary external evaluator.

The overall aim of BSP has been to improve science education in Boston, and to strengthen the STEM pipeline for Boston students from middle school to college level, through new and adapted strategies.

The work of the partnership has been based on a set of goals and a series of strategy models to meet those goals.

The original project goals of BSP were articulated as follows:

- **Goal 1:** Raise student achievement in science.
- **Goal 2:** Significantly improve the quality of BPS science teachers.
- **Goal 3:** Increase the number of students who succeed in higher-level courses in science, and who are admitted to and retained in university science and engineering programs.
- **Goal 4:** Improve science teaching both in BPS and at the universities.
- **Goal 5:** Institutionalize changes so that the Boston Science Partnership and its work will be sustained.

The primary strategies that BSP has utilized to meet those goals are:

- Contextualized Content Courses (CCC)
- Collaborative Coaching and Learning in Science (CCLS)
- Vertical Planning (VP) and Articulation Teams (AT)
- Support—for students and teachers including an AP Support Program; for higher education faculty including institutional policy changes
- Partnership between BPS, UMB, and NEU

A supplement to BSP added goals and strategies involving coordinating and improving community college instruction and other STEM pipeline activities.

THE EVALUATION

PERG has approached the evaluation of BSP through the two lenses of goals and strategies, with the following overarching evaluation questions:

- **Project strategies:** What is the design, implementation, quality, and contribution of each strategy? What are the benefits, issues, lessons learned, sustainability factors, and impacts?
- **Project goals:** Has BSP achieved its 5 project goals? How? What has been the influence of each of the primary strategies on achieving these goals?

In order to answer these questions, PERG evaluators have divided the summative evaluation for the first 5 years of BSP into 2 sections—the Summative Evaluation Report Part 1 focuses on the BSP strategy models and their implementation. The Summative Evaluation Report Part 2 presents findings directly related to project goals. In addition, yearly evaluation reports on the first 4 years of BSP are also available.

Over the course of the project, PERG evaluators employed a combination of qualitative and quantitative data collection methods, including summative surveys in Year 5. Participation data used and analyzed in the reports have primarily been taken from a database created and maintained by the project. Some additional participation data came from PERG surveys. Advanced Placement and all student achievement data have also been provided by project staff. Information about data sources and methodology can be found in each report.

This executive summary includes 3 sections:

- BSP Assumptions and Theory of Change: What Does the Evidence Show?
- Summative Evaluation Part 1: BSP Design and Strategy Models
- Summative Evaluation Part 2: BSP Goals and Outcomes

BSP ASSUMPTIONS AND THEORY OF CHANGE: WHAT DOES THE EVIDENCE SHOW?

The Boston Science Partnership leadership was guided by a theory of change and set of assumptions as they designed and implemented a coherent program to meet the project's goals. After 5 years, evaluation findings and other evidence show how and whether program components based on each of these assumptions contributed to the desired outcomes. Overall, the evidence shows that the theory of change employed by the Boston Science Partnership, and the assumptions upon which it was based, have led to desired outcomes in most cases. (Several areas would benefit from further project implementation and/or further investigation to more strongly support these findings.)

- **Putting BPS at the center of the partnership will ensure BSP strategies meet the actual needs of BPS teachers.**

  The BSP PI from the Boston Public Schools was central to every decision and activity that involved BPS. BPS science department staff often played major roles, as well. (Two different science department directors served as BSP PIs over the course of the project, with some changes in science department staff as well.) These individuals participated in project leadership, and their opinions and ideas were highly respected. They used their experience as teachers and with the district to keep the project activities relevant, targeted, and successful for BPS teachers and students.

  Evidence shows that BPS teachers rated BSP PD highly throughout the project. Teachers overwhelmingly indicated that the CCC courses and CCLS groups were effective in meeting their professional development needs. They were also very positive about Vertical Planning. Teachers who responded to the summative teacher survey indicated that their BSP experiences greatly contributed to changes in their teaching, second only to increased teaching experience. They also reported that these changes had positive effects on their students.

- **Providing high-quality professional development experiences to BPS science teachers to raise their quality and qualifications will have a positive impact on student learning outcomes.**

  BSP offered high-quality, research-based PD opportunities to BPS teachers. The PD primarily focused on strengthening content and pedagogy, and on building connections across the curriculum. Evaluation and other findings have consistently shown that teachers who have been involved in BSP activities have gained content knowledge and increased their use of district-approved, research-based instructional practices. Teachers with more participation in BSP report more changes in their teaching practices over the course of the project, and attribute many of these changes directly to their involvement in BSP.

Evidence of student learning outcomes comes from analyses of student results on the Massachusetts Comprehensive Assessment System (MCAS), a challenging graduation requirement. At the 8^{th} grade level (the only middle school test), evaluators compared changes in passing rates between 2005 and 2009 for students of teachers with different levels and types of involvement with BSP. This analysis showed a positive and statistically significant relationship between BSP participation by teachers and the MCAS passing rates of their students. Changes for different student populations followed the same trends as overall.

High school science MCAS results became available for the first time in 2007, after 3 years of BSP. These subject-specific test results were compared to 2009 results for 9^{th} grade students. No consistent trends were found overall in the achievement levels of the students related to BSP-involvement of the teachers, or for any sub-group of students.

On the summative teacher survey (and through other data collection means), teachers from all grade levels reported being able to better meet their students' learning needs through such BSP-encouraged changes as implementing more inquiry learning strategies, using more differentiated instructional practices, and using more formative and other assessments to inform their instruction, as well as from greater content knowledge and confidence levels.

- **Contextualizing the PD provided to teachers will help ensure transfer to classrooms.**

All major PD strategies of BSP were closely tied to the district curriculum and state standards, and were based on district-approved pedagogical practices. The CCC courses taught content designed to give teachers a deeper understanding of topics tied to particular BPS courses. They also modeled and taught quality pedagogical practices. CCLS groups chose their own course of study, often based on building priorities, district priorities, and/or feedback from the school's student assessment data. CCLS groups also included a classroom observation with feedback for each group member, and a time to look at related student work. The Vertical Planning work primarily focused on understanding and improving curriculum alignment across grade levels and disciplines.

Teachers valued this close connection of the PD to their practice and curriculum. They reported an easy transfer of new content and practices gained in the PD activities to their teaching, which was confirmed by classroom observations. This carryover included increased implementation of mandated curriculum, more use of 7Es (district-endorsed) pedagogical practices, improved labs and ability to connect activities with content, better understanding of student misconceptions, improved assessments and use of assessments, better understanding of the need to differentiate instruction, and a general increased focus on student learning and ability to support student learning for a wider range of students. Teachers also reported increased collaboration with other teachers beyond the PD experiences.

- **Maintaining and building BPS teacher leadership will expand capacity and resources for current and future BPS science education efforts.**

  A strong cadre of teacher leaders was initially trained through a prior and overlapping NSF Urban Systemic Program (USP) grant. BSP utilized this leadership resource and added to it. BSP continued to provide professional development and paid leadership opportunities to existing and new BPS teacher leaders as CCC instructors, CCLS facilitators, in the AP support program, and to VP and Articulation Team participants.

  Many teachers who responded to the summative survey reported taking on new leadership roles since their first involvement with BSP. These roles included new leadership within their school buildings (not including CCLS), as well as new leadership roles in and outside of the district.

  An initial cadre of 20 new NSF/Noyce-funded BSP Science Education Fellows were recruited to become mentor teachers and were expected to provide additional leadership within their buildings and the district; of these, 8 had been CCC instructors, 7 had been CCLS facilitators, and all had been involved with at least 2 of the major BSP strategies, except for 1 elementary and 1 high school teacher who had each been involved with 1 BSP strategy.

- **Involving STEM faculty with BPS teachers will be mutually beneficial.**

  Partnering STEM faculty with BPS teachers on instructional teams for intensive courses for teachers (CCC) was helpful for everyone involved. It simultaneously provided BPS teacher leaders with high-quality content PD and relationships with research scientists, while providing STEM faculty with exposure to high-quality pedagogical approaches and K–12 education involvement. Vertical Planning and Articulation Team activities also brought STEM faculty and BPS teachers together for their mutual benefit.

  STEM faculty consistently reported increased appreciation and respect for teachers as a result of the new working relationships. They also indicated an increase in their interest in, and understanding of, K–12 curriculum and teaching strategies. Furthermore, many STEM faculty reported changing their own college-level teaching to include more active student learning and other new approaches, with positive results for their students. STEM faculty valued the opportunity to learn more about the prior knowledge and experiences of their incoming students.

BPS teachers reported important content gains from their experiences with STEM faculty in CCC courses, and often attributed increased confidence levels to the courses. They valued learning from research scientists, and many established new professional relationships with STEM faculty. In addition, especially through the Vertical Planning and Articulation Team work, BPS teachers learned more about college-level expectations of their students.

- **Bringing BPS teachers and STEM faculty together to vertically and horizontally align and articulate the curriculum will strengthen the STEM education pathway.**

  Vertical Planning work involved BPS teachers along with community college and university STEM faculty in understanding connections across the curriculum and institutions. During the 5th year of BSP, the work consisted of developing "navigation guides," with the goal of strengthening teacher practice and curriculum implementation throughout the district. Articulation Teams also brought together AP teachers, RCC, and UMB STEM faculty who teach similar course levels to clarify expectations of learning from each course.

  Each activity prompted insights about how to better teach and coordinate the science learning experience for students, especially for the BPS participants. Participants reported gaining information about their particular role in the larger STEM education pathway, sometimes changing some of what they cover, when they cover it, or how they present material, as a result. For STEM faculty, especially those not also involved with CCC courses, these experiences provided a much fuller picture of the prior science education experiences of their students, both in content and learning styles.

  Most of the navigation guides have not been completed or implemented, and the conclusions of the Articulation Teams have also not been adopted beyond the small number who participated directly in the activity. If pursued further, both have potential for strengthening the STEM education pathway.

- **PD especially targeted for STEM faculty will help them focus on teaching and learning, and improve their teaching methods.**

  BSP seminars for STEM faculty on issues of teaching and learning have been sponsored by the COSMIC Center at UMB and the Center for STEM Education at NEU. Additional one-time speakers and workshops on instructional practices, for both mixed audiences and for STEM faculty only, have also been sponsored by BSP. The experience of co-teaching CCC courses with teacher leaders, and the specific PD designed to support that effort, has also targeted needs of STEM faculty.

According to evaluation findings, STEM faculty involved with these BSP activities have increased their interest in issues of teaching and learning, and have considered and often adopted new, research-based teaching methods. These new practices include strategies for motivating and engaging students, formative assessment practices, and efforts to help all students learn.

- **Expanding direct supports for AP students and teachers, a greater awareness of the AP program, and better student preparation before reaching AP courses will increase access to and success with this level of academic work.**

  BSP AP support program components included extra lab sessions during the year for AP students; special Bridge to AP science programs during the summer for AP students, with their teachers, on the campuses of university partners; practice AP exams; and additional training and support opportunities for AP teachers. The vertical planning work also helped to increase awareness of AP and improve alignment of the curriculum to better prepare students for such work.

  The number of students taking AP courses in the district increased substantially over the course of BSP, and Black and Hispanic students increased their percentage of the total AP student population. The number of students passing the tests with a score of 3 or higher also increased substantially, although the passing rate peaked and then fell after 2007. In addition, a large number of teachers were newly trained to teach AP courses.

- **Both top-down and bottom-up approaches at IHEs will result in desired changes.**

  Each core university partner garnered administrative support to establish or expand centers for STEM education during BSP. PIs at each institution continued to meet with administrators to build additional support to further BSP goals. In addition, at UMB, a PI organized an annual informal meeting to discuss tenure and promotion issues, and to plan a workshop to help tenure-track faculty with the tenure process, including how to highlight and credit science education activities. In addition, STEM faculty who were most involved with BSP have played important roles, such as on search committees and as informal resources on science education issues.

  The STEM Centers (led and staffed by BSP PIs) have been the focal point for addressing STEM education needs both within the universities and in relation to STEM faculty involvement with K–12 science education. The BSP PIs, along with some other STEM faculty involved with BSP, have gained reputations as sources of knowledge about research on teaching and learning, and about K–12 science education.

As a result of the efforts at UMB, there is now more clarity about the tenure process, especially the value of STEM faculty work in science education. Over the course of the project, several STEM faculty associated with BSP and other science education efforts from both universities have received tenure, promotion, and prestigious university awards.

STEM faculty at UMB experience more support in their departments for a focus on quality teaching and for involvement with K–12 science education. They also report more discussions with other STEM faculty about issues of teaching and learning at the university level. (At NEU, many fewer STEM faculty have been involved with BSP out of a much larger total number. Changes there are focused around the STEM Center, as described above.)

- **Involvement of STEM faculty from community colleges in BSP will add an important link in the efforts to improve science education for Boston students.**

  A BSP supplement provided support for including some community college STEM faculty in Articulation Teams, Vertical Planning activities, and PD events, some specifically targeted for a community college audience.

  Adding community college STEM faculty to BSP was beneficial for all involved. Their participation added new and important perspectives and understandings about the STEM education pathway for large numbers of Boston students. However, there were unanticipated obstacles to full involvement for CC STEM faculty, including a dearth of full-time STEM faculty members and weak organizational systems.

- **An interrelated set of project activities will produce synergies that add benefits beyond those provided by each activity alone.**

  While each of the PD strategies can stand alone, they were designed to compliment each other as part of a coherent whole. The primary goals of each were aligned in such a way to reinforce the others—CCC to emphasize content, but in the context of BPS curriculum and desired pedagogical practices; CCLS to emphasize pedagogy, but in the context of teaching BPS science curriculum content; and VP to emphasize instructional and curricular content alignment. In addition to these mutually supportive design elements, many teachers and STEM faculty were involved with more than one strategy activity, providing further advantages.

Each major strategy activity contributed to the success of the other activities—Year 1 VP work provided the foundation for the CCC courses; teacher leaders, especially CCC instructors, played formal or informal leadership roles in other activities; a culture of supportive and open relationships fostered in CCLS extended to and benefited other activities; deeper content knowledge gained in CCC courses helped to deepen discussion in some CCLS groups; some teachers took the VP articulation approach into their CCLS groups; knowledge of the curriculum across grade levels was built through all strategies and recorded into navigation guides in Year 5 VP workshops.

The comprehensive set of BSP program activities helped to create a sense of change and accomplishment among BPS teachers of science. Another major benefit of the overall program was the creation of collaborative relationships and a strong science education community across the district and across institutions. One expression of this was the teacher-organized "science Fridays," where over 50 science teachers from across the district gather together monthly at local restaurants. Teacher retention may turn out to be another benefit of the combination of activities—of the 184 teachers of science who responded to the summative survey, 70% checked that they would *definitely* want to keep teaching science in BPS for the next 3–5 years, and another 18% checked *probably*.

At UMB, the number of BSP PIs (3), and the relatively high proportion of STEM faculty involved with at least one BSP activity (approximately 1/3), have also encouraged synergies, prompting a growing interest in improving STEM education, both at the university level and K–12.

OVERVIEW: SUMMATIVE EVALUATION REPORT PART 1—BSP DESIGN AND STRATEGY MODELS

This review of evaluation findings related to BSP design and strategy models is based on the full Summative Evaluation Report Part 1.

SIGNIFICANT FEATURES OF OVERALL BSP DESIGN

The Boston Science Partnership consists of a unique combination of features, specifically designed for a large urban school district and 2 universities that serve large urban student populations.

- The BSP models are comprehensive, complementary and flexible, targeting specific goals and needs of these partners.
- Cross-fertilization of participants and complementary design features build synergies.
- BSP has been integral to the work of the BPS science department and vice versa.
- Successful implementation of models depends on a core of strong teacher leaders.
- The partnership includes STEM leadership with a high level of commitment to K–12 science education goals, and also a strong commitment to achieving STEM/IHE goals.
- Activities are designed to benefit all teachers and STEM faculty involved in any capacity.
- Community college participants add a crucial link in the 6–16 STEM pipeline.

The current BSP PD strategy models are very attractive to BPS teachers and STEM faculty who are involved with them. Teachers like these models for many reasons, most notably for the following features:

- Focus on high-quality content knowledge and pedagogy
- Contextualization to the district curriculum and preferred pedagogical model
- Learning that is easily transferable to the classroom
- Explicitly science-focused
- Vertical information about the curriculum
- Cross-level and cross-institution interactions

- Role for teacher leaders
- Contact and collaboration with STEM faculty

STEM faculty like the models that include them or are designed for them in particular, most notably for the following features:

- Opportunity to teach and collaborate with 6–12 teachers
- Focus on 6–12 science curriculum and connections across curriculum 6–16
- Attention to issues of teaching and learning

BSP Strategy Models

BSP has created and implemented a number of professional development and other models, many of which were adapted from prior efforts by other groups. Each has its own particular goals and key features. (The body of this report contains a thorough discussion of each of these models.)

Contextualized Content Courses

The primary goal of the Contextualized Content Courses (CCC) has been to provide challenging content courses for science teachers in the context of the Boston Public School's curriculum and district-approved pedagogical practices.

The outstanding features of this model are:

- **STEM faculty and two 6–12 science teacher leaders collaborate to develop and deliver the courses.**

  This collaboration ensures the deep content and full contextualization of the courses. It also provides excellent professional development opportunities for both the STEM faculty instructors and the teacher leader instructors.

- **The course content is contextualized to the district curriculum.**

  CCC courses are matched to specific BSP courses or kits, and provide deeper content knowledge and more challenging investigations to give teachers more depth, experience, and confidence to teach those courses.

- **BPS teacher leaders model effective, district-approved pedagogical practices during the courses.**
- **Differentiation of instruction, to provide appropriate challenge and support to each participant, is an important goal.**

Collaborative Coaching and Learning in Science

The primary purpose of CCLS is to provide high-quality science professional development within the context of each school.

The outstanding features of this model are:

- **CCLS is a school-based, teacher-driven professional learning community model that can be contextualized to a variety of needs**.

  There is a specific protocol for the meetings, but the particular focus is determined by the group.

- **Meetings encourage the creation of a culture of supportive relationships and attention to meaningful issues of teaching and learning.**

  Groups that cannot achieve this on their own receive help from the district staff.

- **CCLS can function well with variable levels of district support, and can become autonomous relatively quickly with an effective facilitator.**

  District staff provide training in the model to the facilitators, sometimes in group sessions, but especially through individualized support visits to CCLS meetings.

- **The CCLS model calls for classroom observations of each group member, inquiry research, and looking at student work.**

  New groups can add observations as they build trust, if necessary.

Vertical Planning

The primary goal of the BSP Vertical Planning work over the course of the project has been to build a greater understanding of the entire science curriculum, from grade 6 (or earlier) through university level.

The outstanding features of this model are:

- **STEM faculty and 6–12 or K–12 teachers meet together and collaborate by discipline to examine key content, "enduring concepts," and skills across grade levels.**

  Educators trace important topics and skills across a student's academic experience.

- **This process can be used to better align the curriculum and enacted curriculum to support AP success.**

  VP can focus teacher awareness on AP and pre-AP student needs, highlighting the role of teachers of younger students in preparing them to succeed in AP classes.

- **The Vertical Planning *process* encourages meaningful discussions about curriculum and practice across grade levels.**

- **Vertical Planning activities can include a *product* to focus the work and share the results.**

  BSP navigation guides focus on expectations of students entering and exiting each course; they detail priority content and skills to cover each year, and how each year fits into the K–16 continuum of science learning.

Articulation Teams

Articulation teams are a model developed by a BSP supplemental grant, and are closely related to Vertical Planning. Their primary goal is to increase coordination around STEM instruction among BPS AP teachers, community college STEM faculty, and IHE STEM faculty who teach similar level courses.

The outstanding features of this model are:

- **Teams of educators teaching the same discipline compare curriculum topics/syllabi, labs, pedagogical practices and assessments.**

  Through this process, they ascertain similarities and differences in goals, content, skills, and structure of the courses.

- **Team members engage in activities that allow them to discover common student misconceptions and errors.**

  Team members compare assessments and often give similar exam questions or homework problems to analyze and compare student responses.

- **Team members gain an understanding of how to best facilitate continuity in student learning across particular institutions.**

  This process provides an understanding of how to best advise students across institutions.

AP Support Program

The primary goal of the AP support program is to increase BPS student access and success in higher-level courses and in STEM pathways.

The outstanding features of this model are:

- **A cohesive and comprehensive program with several components provides a foundation of supports for urban students and their teachers.**

  This provides access for many more students to advanced work. The program also trains and supports more teachers to teach AP courses.

- **Teachers and students build a strong classroom community outside of school.**

  Starting the summer before class begins, and continuing during the year, entire classes participate in extra activities together.

- **Local IHEs provide access to additional resources on their campuses.**

  Classes get to do AP labs in university facilities; universities get promising high school students familiar with their campuses.

IHE STEM Faculty Seminars

The primary goal of the STEM faculty seminars held at both partner IHEs is to improve the teaching of STEM faculty.

The outstanding features of this model are:

- **Seminars focus on STEM teaching issues.**

  Both universities have other centers with a mission of improving teaching on campus. STEM faculty seminars address issues of teaching STEM subjects exclusively, and give STEM faculty a chance to think about these issues with their department and college colleagues.

- **Seminars include research about teaching and learning.**

  The purpose is to make faculty aware of the existence of such research, as well as its findings.

- **Seminars utilize a flexible and varied approach.**

  There is an interest in these topics among STEM faculty. However, since these topics are not traditionally valued at research institutions, creative and changing approaches are used to reach new faculty and retain existing participants.

Advancing Tenure and Promotion Issues

This strategy is not a professional development strategy, but rather is aimed at changing the policies and culture at the IHEs in support of involvement by STEM faculty in K–12 science education.

The outstanding features of this model are:

- **Create opportunities for informal discussions about the reward structure in relation to work with K–12 science education.**

  Varying groups of provosts, deans, department chairs, tenured and pre-tenured faculty are invited to share thoughts about these issues in small informal meetings.

- **Conduct workshops for pre-tenured STEM faculty.**

  Special workshops for pre-tenured STEM faculty include information about how to present K–12 science education-related work.

Including Community Colleges in STEM Pipeline Efforts

This strategy was added by the supplement in Year 3. The primary goal is to recognize the key role of community colleges in the STEM pipeline.

The outstanding features of this model are:

- **Add local community college STEM faculty to STEM pipeline activities.**

  Community college STEM faculty are a key link in the STEM pipeline experience of many students.

- **Community college STEM faculty receive professional development.**

  Community college STEM faculty do not have access to many PD opportunities, especially PD designed specifically for STEM faculty.

OVERVIEW: SUMMATIVE EVALUATION REPORT PART 2—BSP GOALS AND OUTCOMES

This review of evaluation findings related to the BSP goals and outcomes is based on the full Summative Evaluation Report Part 2. Some of the goals address the same populations, and therefore are grouped together. Goals 1 and 3 both relate to students, and have been combined below. Goal 2 and part of Goal 4 (4a) relate to BPS teachers, and those sections have also been combined. The part of Goal 4 (4b) that relates to teaching at the partner universities has been addressed separately.

GOAL 1: RAISE STUDENT ACHIEVEMENT IN SCIENCE.

GOAL 3: INCREASE THE NUMBER OF STUDENTS WHO SUCCEED IN HIGHER-LEVEL COURSES IN SCIENCE, AND WHO ARE ADMITTED TO AND RETAINED IN UNIVERSITY SCIENCE AND ENGINEERING PROGRAMS.

The ultimate purpose of the project is to raise student achievement in science and to increase the number of students in the STEM education pipeline. (Evaluation and research on student STEM pipeline-related goals has been conducted by SageFox Associates and UMB researchers. The EDC research group has also analyzed student achievement results in relation to their research questions. All of those results are reported elsewhere.)

Standardized Test Results

To assess changes in student achievement in science, the evaluation used the Massachusetts Comprehensive Assessment System (MCAS), a challenging test based on state science standards and frameworks. Student passing rates were determined for groups of teachers, based on their level of participation in BSP. At the 8^{th} grade level, rates from 2005 and 2009 were compared. The first non-pilot high school test was given in 2007, and that was the first freshman class that needed to pass one science test in order to graduate. The 2007 passing rates (which was the third year of the project) were compared to 2009 passing rates for tests in physics and biology. Only 9^{th} grade results were included in the analysis, in order to assure that only a student's first time taking the test was considered.

- Middle school (8th grade) results show a statistically significant relationship between BSP participation and increased student passing rates. Those who participated in more BSP activities had students with higher passing rates, and also saw the strongest increase in passing rates over time.
- Those who participated in only one type of BSP activity also showed strong improvements in passing rates. Vertical Planning experiences appear to confer additional benefits for middle school teachers who have attended other BSP activities.
- High school physics results do not show a clear relationship between passing rates and amount of BSP participation.
- On the high school biology test, students of teachers who participated in the most BSP activities passed at the highest rate (93%) in 2007, and also increased their rate the most, to 97% by 2009.

Advanced Placement Enrollment and Test Results

Advanced Placement course students were the students most directly involved with BSP programs. The project provided a variety of direct and intensive supports for AP students with extra school-year and summer activities on university campuses. (Training and support was also available to AP teachers.) This program began in the second year of the project and grew into a comprehensive approach by the fifth year. Changes in AP course enrollment and test passing rates are useful indicators of changes for students in advanced science courses. (No teacher correlations were possible with the data available.)

- Student enrollment in AP courses doubled between 2005 and 2009.
- Black and Hispanic students increased their percentage of the total AP student population between 2005 and 2009, although still lag behind their percentage of total district enrollment.
- The number of students passing an AP test with a score of 3, 4, or 5 increased by two-thirds between 2005 and 2009.
- Passing rates rose between 2005 and 2007, and then declined by 2009 below baseline rates overall. (Chemistry and physics rates remained above the 2005 rates.)

SAT Science Subject Tests

SAT Science Subject Tests are generally taken by students who are interested in pursuing science and/or are reasonably confident of doing well on them. Thus, increases in the number taking the test and the mean scores might reflect overall improvements in the science program in the district, at least for the population most likely to continue in the STEM pathway. While there is no clear data linking BSP with these outcomes, it has been the primary provider of professional development to BPS middle and high school teachers during this time. (Only aggregate data was available from the College Board.)

- The number of BPS students who have taken SAT Science Subject Tests has more than doubled between 2004 and 2009.
- The mean scores have risen in each discipline except chemistry, where they have dropped slightly; however the number of students taking the chemistry test more than tripled.

Goal 2: Significantly improve the quality of BPS science teachers.

Goal 4a: Improve science teaching In BPS.

A primary goal of BSP was to improve science teachers and teaching in the Boston Public Schools. This included improving the quality of science teaching as well as increasing the number of teachers certified to teach each science section assigned to them. (EDC research results report on gains in licensure and teaching assignment.)

According to evaluation findings, all types of Boston teachers credit BSP professional development activities with major positive influences on their lives as teachers and for contributing to major changes in their teaching practice. These include teachers from all grade levels; all levels of experience teaching science; ELL and special education teachers; whether or not they are licensed in science; teacher leaders, including former USP teacher leaders; and those involved at all levels of participation in BSP. In addition, the types of changes to their practice reported by teachers are consistent, regardless of the amount of participation in BSP or the amount of change reported.

According to strategy-specific and summative teacher surveys, interviews, and observations, BSP contributed to numerous and varied positive changes on the part of BPS teachers, including:

- **Content knowledge, pedagogical approaches, and pedagogical content knowledge**

  Evaluation findings consistently indicated gains in content knowledge and new pedagogical approaches for teaching science for the overwhelming majority of participants due to their participation in the major strategies, especially from CCC and CCLS, but also from VP. Teachers also consistently indicated an ease of transfer to their classrooms. This was aided by the contextualization of each strategy to both the curriculum and district-approved pedagogical practices—the content courses (CCC) included modeling of how best to *teach* those topics; the school-based PD experiences (CCLS) addressed pedagogical approaches for teaching *science* topics. And content and teaching strategies were also intertwined at the Vertical Planning events.

- **Knowledge and understanding of the curriculum**

  Each major strategy activity contributed to teacher knowledge and understanding of the BPS curriculum. This included curriculum for one's own grade level or content area, as well as curriculum for other grade levels and content areas.

- **Confidence**

  Many teachers reported having greater confidence as a teacher due to their participation in BSP activities, especially as a result of increasing their content knowledge.

- **Science teaching support network**

  Each major BSP strategy was credited with increasing and improving relationships between teachers. Teachers changed and improved the nature of their relationships with building colleagues, increased the frequency of their conversations about science teaching, and formed new relationships with other BPS teachers across the district. Teacher leaders initiated monthly *Science Fridays* at local restaurants, which were well attended by science teachers from across the district. And new professional relationships were also established with STEM faculty.

- **Leadership**

  BPS teachers involved with BSP increased their leadership activities with new roles—within their schools, the district, and elsewhere.

Evaluation findings show benefits for particular populations of teachers:

- **CCC Instructors**

  The majority of CCC instructors were already trained to be teacher leaders by a prior and overlapping USP grant. Nonetheless, they benefited from the experience of participating in specific PD for the instructional teams, helping to plan the courses, and from co-teaching with another teacher leader and a STEM faculty member. Almost all of them attributed many positive changes in each of the areas above to their involvement with BSP.

- **Longtime science teachers**

  Ninety-five (95) educators who have been teaching science for more than 6 years completed the summative teacher survey. This group reported that participation in BSP activities contributed to an increase in their content knowledge and confidence level, as well as many other changes to their teaching. These changes are also present for those teaching science for over 16 years, with high percentages of this group also reporting changes in all other areas included in the survey. (While many of those teaching for 3–5 years also reported changes, a much smaller percentage of newer teachers reported changes in many categories.) This would appear to indicate that the BSP strategies were successful in impacting the knowledge and practice of longtime teachers.

- **ELL and special education teachers of science**

  High percentages of ELL and special education teachers of science who responded to the survey also credited BSP with helping to increase their content knowledge and confidence levels, as well as with prompting them to make changes to their teaching. An especially high percentage of special education teachers gained content knowledge and confidence for teaching outside of their area of licensure. They also reported changing their teaching strategies, including differentiated instruction practices. An especially high percentage of ELL teachers gained content knowledge and confidence for teaching within their licensure, and changed teaching strategies and content taught in their courses. It was also an opportunity for these teachers to share information about meeting the learning needs of their students with other teachers.

- **Teachers without a license in science**

  Forty-three (43) teachers who responded to the survey indicated that they are not licensed to teach science. (This includes elementary school teachers.) Especially high percentages of these teachers indicated that their participation in BSP helped them gain content knowledge and confidence for teaching outside their licensure, and to change teaching strategies, including differentiated instruction practices.

- **USP (Urban Systemic Program) teacher leaders**

  The BPS science department trained a cadre of science teacher leaders through an NSF Urban Systemic Program grant before and during the beginning of BSP. Many of these teachers provided early and ongoing leadership for BSP PD activities, receiving benefits from those roles. While it is difficult to fully separate the influence of each project on these teachers, many USP teachers attributed a number of changes to their involvement with BSP, including increasing their content knowledge, confidence level, and knowledge of a wider variety of teaching strategies as a result of the project.

GOAL 4B: IMPROVE SCIENCE TEACHING AT THE UNIVERSITIES.

Another major goal of the Boston Science Partnership was to improve science teaching at the universities. BSP provided STEM faculty with several opportunities to expand their knowledge of issues of teaching and learning, both in conjunction with BPS teachers and with other STEM faculty only. According to evaluation findings, tenured and untenured STEM faculty, with a range of years teaching, credit BSP with changing their approach to teaching.

BSP contributed to numerous and varied positive changes for STEM faculty, including:

- **Greater interest in issues of teaching and learning**

  STEM faculty at both partner IHEs expressed a greater interest in issues of teaching and learning at the higher education level. They also indicated thinking about these issues more frequently. Many were introduced to the body of research in this area for the first time.

- **Change in value placed on classroom activities, including more value on active student learning**

  The value STEM faculty place on particular undergraduate or graduate class activities changed as a result of their involvement with BSP. Almost a third of those responding to the summative STEM faculty survey now place less value on lecturing, and the majority place more value on different forms of active student learning than before. Many also now place more value on review of prior student knowledge, formative assessment activities, and on activities differentiated according to student abilities.

- **Consideration of new approaches to teaching and teaching changes**

  STEM faculty were exposed to new approaches to teaching through their contact with BPS teachers, as well as through STEM faculty seminars on that topic. Many reported changing their teaching to include more active student engagement, including inquiry learning and use of a wider variety of activities and approaches. STEM faculty also reported more engagement, content understanding, and ability to use the scientific method on the part of their students as a result.

- **Expanded community of STEM faculty interested in issues of teaching and learning**

  STEM faculty at UMB, where a larger number and percentage of STEM faculty were involved with BSP, report more discussions with other STEM faculty about issues of teaching and learning at the university level. They also experience more support for a focus on quality teaching in their departments.

- **Greater understanding of K–12 science curriculum and teaching methods**

  STEM faculty who participated in activities with K–12 teachers learned about the prior curriculum and teaching methods experienced by their students. They valued this opportunity, and some used the new knowledge to adjust the content, approach, or expectations of students in their classes.

- **More interest in and support for K–12 science education**

  Some STEM faculty involved with BSP activities indicated that they now have a greater interest in being involved with K–12 science education, including through research, grants, and teacher-training efforts. STEM faculty at UMB report more support for involvement with K–12 science education in their departments than before BSP.

One population of STEM faculty in particular experienced extensive gains:

- **CCC instructors**

  While some CCC STEM faculty instructors had prior experience in teacher education, many did not. Most attended specially-designed PD to prepare them to teach teachers, as well as receiving extensive on-the-job training from high-quality teacher leaders with whom they planned and taught the courses. This also meant an immersion into some aspects of K–12 science education and curriculum. As a result, they reported many gains in their understanding of, valuing of, and ability to implement new pedagogical approaches in their university courses. Every CCC instructor who responded to the STEM faculty survey indicated that their college-level students improved their understanding of science content and their ability to use the scientific method as a result of their BSP-inspired instructional changes. Some STEM faculty reported adopting a new goal of helping *all* of their students to succeed in their courses as a result of similar expectations in their CCC courses. Finally, this group of STEM faculty also built new, professional relationships with BPS teachers based on mutual respect.

GOAL 5: INSTITUTIONALIZE CHANGES SO THAT THE BOSTON SCIENCE PARTNERSHIP AND ITS WORK WILL BE SUSTAINED.

A final goal of BSP is to institutionalize changes at the partner institutions, and to have those changes and the work of BSP be sustained beyond the project. According to evaluation findings, each institution has experienced important changes during the course of the project that are related to their involvement with BSP. These institutional changes include cultural shifts, new programs, and other new developments. At each partner institution, BSP benefited from and built on prior efforts with complementary goals. While the initiatives most dependent on BSP funding are challenging to sustain without additional outside funds, many aspects of BSP will remain. And the work of BSP at each institution is already serving as a building block for new initiatives.

Boston Public Schools

Institutional changes at BPS that can be linked to BSP include:

- A strengthened and more dynamic science department
- Higher visibility for science education in the schools
- More appreciation for the importance of deep content learning professional development
- Increased understanding of curriculum connections
- Changes in the nature of teacher interactions
- Additional roles for science teacher leaders
- Increased number of licensed science teachers
- Advanced Placement Program supported by university partners
- Stronger connections with STEM faculty and local universities

Sustainability has been heavily influenced by the impacts of ongoing district budget cuts at BPS. These severely limit the ability of the district to support continuing CCLS and VP work, although some of that work continues without district assistance. Support for attending CCC courses is no longer available from the project, although several courses are still offered. The AP support program enjoys administrative backing, and at least some parts will likely continue with IHE resources. BSP supplemental funding will continue to support a number of BPS teacher leaders through a Science Education Fellowship program. These teachers are expected to play key leadership roles in their schools and the district, and may be able to continue some of the BSP activities. The biggest ongoing footprint left by the project will likely be the teachers and teacher leaders who have been affected by it. If the majority of these teachers stay in the system, they may help science education in the district continue to progress, although both of those outcomes will be more likely if a robust district science department can be maintained.

University of Massachusetts Boston

Institutional changes at UMB that can be linked to BSP include:

- Greater university-wide interest, involvement, and reputation for STEM education issues
- Expansion of the role of the COSMIC Center
- More focus on, valuing, and interest in K–12 STEM education

- More attention to undergraduate teaching
- Tenure and promotion changes to support STEM education work
- New science education course offerings
- Collaboration with BPS on Advanced Placement programs

Beyond BSP, it appears that STEM education issues will continue to be a priority for UMB, with the COSMIC Center in a central, integrating role. It also appears that shifts related to tenure and promotion, especially in support of K–12 science education involvement, will also remain. In many ways, BSP has helped to prepare the university, and STEM faculty in particular, to increase its STEM education involvement even further. To reach its full potential, this work may require increased collaboration between the College of Science and Mathematics and the Graduate College of Education at the institutional level.

Northeastern University

Institutional changes at NEU that can be linked to BSP include:

- Creation of a Center for STEM Education
- Master's program for middle school science teachers
- New science education course offerings
- Increased attention to the importance of STEM teaching and learning issues
- Collaboration with BPS on Advanced Placement programs

The institutional changes at NEU linked to BSP are likely to be sustained as long as various grant funding continues. The Master's program and CCC courses will need continued support, but so far Massachusetts Department of Education grants are meeting that need. With the encouragement of the BSP PI, there appears to be an increased interest in strengthening STEM teaching at the university. While several structural changes have occurred at Northeastern, there has not been a concurrent cultural change among STEM faculty, at least thus far. Hopefully, expanded efforts will begin to reach more deeply into the faculty population.