

MATHEMATICS AND SCIENCE ADVISORY COUNCIL
Annual Report
June 2008

I. EXECUTIVE SUMMARY

Professional development (PD) is education for teachers, and effective PD is as crucial as effective education for students. Characteristics of effective PD in mathematics and science include deep subject content, sustained and coherent programs, and involvement of mathematicians and scientists. Within Massachusetts, there are exemplary PD programs of many varieties. In contrast, other PD programs in Massachusetts appear to be superficial and short, and more a delivery vehicle for PDPs or graduate credits than an investigation of fundamental mathematical and scientific concepts. The current cursory DESE certification process for PD programs allows weak programs to persist, both at the district level and at IHEs (Institutes of Higher Education).

Teachers have difficulty finding out about PD opportunities outside their individual districts, and receive little guidance on the quality of PD offerings. A comprehensive state database of PD opportunities, combined with a more rigorous certification process for local and IHE PD offerings, would address both issues and greatly benefit Massachusetts teachers.

II. INTRODUCTION

In the Department of Elementary & Secondary Education's Framework for Leadership and Action, professional development (PD) is explicitly listed as a Lever underlying the fundamental mission of improving the public education system. As such, the Department understands that PD, i.e. the continuing of teachers' own education, is crucial to children's education. Because of the broad agreement on the importance of PD, this year's report of the Mathematics and Science Advisory Council (MSAC) focuses on PD programs in these areas in Massachusetts.

There is certainly no one model of PD that is best in all situations. Nevertheless, there is a body of research that identifies key characteristics of effective PD, including intensive investigations of fundamental subject content relevant to the classroom, presented in a coherent and sustained fashion, and ideally with input from practicing mathematicians and scientists. Despite this consensus, there are valid disputes over the balance of content versus pedagogy in PD programs, what constitutes "relevant" math and science, and similar issues. These healthy debates should and will continue.

There are many excellent PD programs in Massachusetts and other states, with varied implementations of the key characteristics of effective PD, and the MSAC has identified a sampling. These programs embody the Framework's ideal of "preparing all students to succeed," and should be viewed as shining examples to replicate. At the same time, there is much anecdotal evidence of PD programs in Massachusetts that embody the opposite of these characteristics. These programs treat mathematics and science content at a superficial level, can be as short as six hours, and have leaders with perhaps very limited subject knowledge. There is evidence of equally weak graduate level courses providing less

subject content than standard undergraduate courses, underlining the need for a reassessment of the state's requirements for advanced degree work for teachers.

Unfortunately, the Department's current cursory approval process for PD programs allows these questionable PD programs to persist. Similarly, the quality of advanced undergraduate and graduate courses for teachers at IHEs is subject to light review at best by the Department. This lack of oversight is not limited to the Department: if these courses are offered by an IHE's continuing education program, they are often not subject to review by IHE mathematics or science departments. These problems are exacerbated by the pressure on teachers to enter advanced degree programs, where state guidelines forbid them from taking any needed undergraduate level content courses. In some cases, the result is unchallenging PD programs that provide the PDPs or graduate credits necessary for teacher advancement but which do very little for the teacher or his/her students. At its worst, the PD system devolves into what one Council member called a "racket." As such, the Department is neglecting its own Frameworks Action Principle of "promot[ing] high standards and accountability for results." A more rigorous initial vetting process for PD programs, a more rigorous evaluation of IHE courses that are part of PD programs, and more rigorous final accountability measures than the current easily massaged pre/post-tests, while nontrivial to construct and to finance, are necessary to produce a statewide offering of PD courses that embody Board of Higher Education and Department principles.

At present, Massachusetts math and science teachers who want to find challenging, valuable PD programs find themselves doubly frustrated: they often do not know how to find out about PD opportunities outside their districts, and when they do find some listings (such as the Department's listing of Summer Professional Development Institutes), they have difficulty judging the quality of individual PD programs. A more rigorous approval process for PD programs combined with a Department webpage of all approved programs would give teachers the confidence that the listed programs are worthwhile continuations of their own education. The vast majority of our teachers recognize strong PD programs as crucial for their students' education, and we owe it to these teachers to provide them with good quality assurance.

III. 2007-2008 ISSUES AND ACTIONS

In order to increase the effectiveness of teacher instruction in mathematics and science classrooms, the Council identified the primary goals of Professional Development. This task, which at first glance may appear obvious, required long discussion. The agreed upon goals, in the order of importance, are:

1. To increase the content knowledge of the teaching force in mathematics and science. All teachers should develop content knowledge at a level substantially above the level at which they teach;
2. To foster essential habits of mind, to make deep conceptual connections, and to therefore enrich teachers' mathematical and scientific dispositions and their relationship with the subjects they teach. This can be accomplished by engaging teachers in immersion experiences that are authentic to the subjects; and
3. To improve classroom performance by exposing teachers to effective (frameworks-based) instruction and by explicit discussions of such practices.

Item 1 requires graduate level courses and programs in mathematics and science that are rooted in the mathematics and science of the K-12 curriculum. In many cases, such courses will need to be developed, and many teachers will need preparatory work before they can succeed in these courses. But there is substantial evidence (see Appendix C: References) that the content of K-12 mathematics and science can be made the basis for serious professional development at the graduate level.

As mentioned, not all STEM teachers currently are capable of taking graduate level courses in their disciplines. The existing requirements that these teachers take graduate courses for advancement within their districts has led in some cases to the creation of IHE STEM courses that are graduate level in name only. In many cases, teachers would be better served by challenging undergraduate level STEM courses designed for teachers. The Department should reevaluate its advanced degree requirements and its criteria for certifying PD courses as graduate level.

Item 2 is based on the fact that when teachers engage in an intense immersion experience that involves solving well-selected challenging problems, they develop an approach to the subjects they teach that is faithful to the discipline itself. It is desirable that an immersion experience be an integral part of the content courses in Item 1, because this helps teachers develop the mathematical and scientific disposition needed for success in such courses. In immersion experiences, participants experience authentic processes of trial and error to search for concrete examples, counterexamples and approaches to guide and polish their own intuition through individual and group work. They make educated guesses, construct models, and then subject them to logical scrutiny – precisely the same processes used by mathematicians and scientists in problem solving. Research cited below shows that one of the hallmarks of high-performing countries is that they employ curricula and teaching practices aligned with how ideas are organized in the discipline. Good examples in Massachusetts are the DESE funded Intensive Immersion Institutes (I³ of EduTron) and the NSF funded Focus on Mathematics (FoM of EDC/BU). (See Appendix B for more examples of PD programs and Footnotes 1 and 2 for Council member involvement.)

Item 3 is the object of a great deal of current research, cited in Appendix C.

Professional development should be sustainable and should induce positive long-term impact. Highly effective professional development is expected to instill in teachers the love of both their subjects and their teaching, and should ignite teachers' desire to improve their content knowledge and instruction on a continuous basis. Professional development should also aim to develop communities of teachers, administrators, and IHE faculty who are committed to collaboration for continual learning, and to encourage high expectations and enthusiasm. The Teacher Leader Concept from last year's report remains a viable approach in enhancing sustainability.

In contrast to the ideals just listed, the Department, school districts and the individual teachers face many obstacles to effective PD. Science and mathematics teachers are in short supply, due in part to competition from the corporate world for individuals who have the requisite knowledge and skills in these areas. Schools budgets are very tight, and many towns have faced straitened conditions that can only be ameliorated through Proposition 2½ overrides or reductions in services. The limitations on compensation and resources for teachers further impede recruitment and retention of science and mathematics teachers. In addition, many teachers report that the pressure for students to pass the MCAS tests dictates the material that is taught and also drives a district's expenditure of professional

development money towards only those efforts that will immediately lead to a demonstrable change in students' scores on mandated state tests.

At their worst, PD offerings become either a platform for a "person who wants to teach something," or they rely on grant funding that provides short-term PD that meets the needs of the granting agency and/or the PD provider rather than the needs of the teachers. Neither of these approaches is likely to result in a cohesive, sustainable, goal-oriented, performance-based view of PD for teachers. As a result, teachers can accumulate graduate course credits or PDPs in a haphazard array of programs of dubious quality and effect.

This scattershot approach to PD hurts both our teachers and our students. We have excellent mathematics and science PD programs and resources within Massachusetts to train teachers in the critical thinking skills and habits of mind we wish to pass on to our students. Ensuring that our PD programs serve these goals will require the commitment of time and resources from the Board and the Department.

IV. COUNCIL RECOMMENDATIONS

Detailed recommendations are in Appendix A.

Our general recommendations are as follows:

1. The state should publish guidelines for high quality professional development offerings in mathematics and science. Mandatory and desirable characteristics should be included in the guidelines. Exemplary practices should be highlighted.
2. The state should establish processes for certifying high quality in-service professional development courses in mathematics and science.
3. The state should make explicit to all parties involved that the effort to provide high quality professional development will require close collaboration among university departments in the natural sciences and mathematics, the education departments at their institutions, and institutions, organizations and corporations with proven track records.
4. The state should provide sufficient funding to support both the development and the implementation of high quality professional development activities in mathematics and science. Examples of such support include:
 - tuition reimbursement for graduate credits that accompany participation in high quality mathematics and science professional development.
 - stipends to fund participation in collaborations among teachers, mathematicians, scientists, education researchers in STEM disciplines, and members of museums and other educational institutions for the purpose of developing graduate level, discipline-based professional development programs that are customized to teachers' needs.

5. The state should convene an expert group to study possible effective quality control mechanisms for professional development in mathematics and science, and to reevaluate the current graduate level requirements for advancement.

V. COUNCIL DETAILS

Administrator: Barbara Libby

Council Liaison: Jacob Foster, Sharyn Sweeney

Chairperson: Steven Rosenberg

Members of the 2007-2008 Advisory Council: Andrew Chen, Al Cuoco, Solomon Friedberg, Kelley Gangi, Barnas Monteith, John Mosto, Reza Namin, Mary Porter, Nitzan Resnick, Carla Romney, Steven Rosenberg, Sandra Ryack-Bell, Farideh Seihoun, Wayne St. Peter, Amy Wolpin, Deborah Wright

Council Meeting Dates: January 14, 2008; February 12, 2008 (cancelled due to snow); March 17, 2008; April 15, 2008; May 19, 2008.

APPENDIX A

DETAILED RECOMMENDATIONS

In addition to the general recommendations of Part IV, the Council has the following more specific recommendations:

Elementary Mathematics

1. The recommendations in the following three documents carry important relevance with respect to the professional development needs of elementary teacher, even though some are written with pre-service courses in mind. These documents should be followed closely by professional development providers as guides to the planning and implementation of high quality courses.
 - Massachusetts Guidelines for the Mathematical Preparation of Elementary Teachers <http://www.doe.mass.edu/boe/docs/1207/item3.html>
 - *No Common Denominator—The Preparation of Elementary Teachers in Mathematics by America’s Education Schools* (to be released on June 26, 2008). This in-depth study by the National Council on Teacher Quality addresses desirable course content levels, reviews existing course syllabi, textbooks, and tests/quizzes from a large number of colleges in the US (<http://www.nctq.org>).
 - **Foundations for Success: Report of the National Mathematics Advisory Panel.** This Presidential panel emphasizes the importance of preparing elementary children for success in algebra (<http://www.ed.gov/about/bdscomm/list/mathpanel/index.html>).
2. Successful models of elementary school mathematics professional development, especially the ones in Massachusetts, should be made exemplary.
3. As algebra becomes more prominent as a grade 8 option, districts that organize around a K–8 structure will need to provide programs that prepare elementary teachers for this role. One longstanding and successful program is the Chicago-Based Algebra Initiative: <http://www.math.uic.edu/ome/alginit.html>.

Middle and High School Mathematics

Successful models of middle and high school mathematics professional development, especially the ones in Massachusetts, should be made exemplary. Examples include:

- Intensive Immersion Institutes (EduTron, Massachusetts). These courses provide an intense immersion experience that allows teachers to take risks and bond with mathematics in a collegial, safe, and positive environment. Teachers are challenged with non-trivial world-class problems. They struggle to find the solutions and compare approaches with peers. The interaction in the courses also models standards-based instruction, including multiple grouping strategies, ongoing formative assessments, differentiation, multiple representations and more. The immersion experiences have led to: a large number of teachers taking and passing MTEL; the formation of

local learning communities in the form of grassroots teacher-run content workshops and math clubs for teachers. The teachers' desire to learn more mathematics is evident.¹

- Focus on Mathematics and PROMYS for Teachers (EDC/BU, Massachusetts): These courses encourage teachers to know mathematics from many perspectives.
 - They know mathematics as a scholar: they have a solid grounding in classical mathematics, including its major results, history of ideas, and connections to precollege mathematics.
 - They know mathematics as an educator: they understand the habits of mind that underlie major branches of mathematics and how they develop in learners, including algebra, geometry, and analysis.
 - They know mathematics as a mathematician: they have experienced a sustained immersion in mathematics that includes performing experiments and grappling with problems, building abstractions as a result of reaction on the experiments, and developing theories that bring coherence to the abstractions.
 - They know mathematics as a teacher: they are expert in uses of mathematics that are special to the profession, including the ability “to think deeply about simple things”, the craft of task design, the ability to see underlying themes and connections in school mathematics, and the “mining” of student ideas.²

- Other examples from out of state include the Park City Mathematics Institute for Secondary Teachers (<http://pcmi.ias.edu/>) and the Algebra Initiative previously referred to.

It is crucial that the state find ways to establish and support mathematical communities of mathematicians, mathematics teachers, and mathematics educators. As essential as quality coursework is, equally essential is that we establish solid connections between the people who advance knowledge in a discipline and the people who teach our children about that discipline. This is important at every grade level, but it is especially important in the middle and high school grades.

Elementary Science

- Graduate level professional courses should be developed which deliver the content of a full year of introductions to STEM disciplines and which are taught by faculty in the discipline.

- These classes would be raised to the graduate level by a separate writing and discussion section designed and taught by education specialists, in which teachers consider appropriate teaching and learning applications of the content knowledge base for their grade level, including consideration of cognitive and language development, active inquiry learning, and classroom practices.

¹ *Does Teacher Professional Development Have Effects on Teaching and Learning? Evaluation Findings from Programs in 14 States*, CCSSO (2008). Note: Andrew Chen, MSAC member, is a paid employee of EduTron

² Al Cuoco and Steven Rosenberg, MSAC members, are or have been paid employees of Focus on Math, PROMYS, and/or PCMI.

- These graduate level courses would meet requirements for ongoing professional development, and also should lead to a state certification as an Elementary Science Specialist, with a suitable pay increment. DESE should develop qualifying examinations for this certification.

Middle and High School Science

- Content in PD courses should be delivered at the upper division or graduate level. Many upper division science courses are already offered with an additional component to raise them to graduate level, and education departments could adapt this strategy to professional programs. Such courses would meet professional development requirements, and also carry graduate credit towards pay scale increases.
- Appropriate courses should include health and clinical science as well as biology, chemistry, physics, and earth and space sciences. Science and engineering teachers already certified in one area should be offered this as a means to add certification in a second science (especially the quantitative sciences) by completing the introduction to the discipline and a cohort of the upper division and graduate content courses leading to an MS in Science Education (MSSE). The MSSE would carry an appropriate pay scale increment, and DESE should develop an exit test, which would serve as a common evaluation tool for content area professional development programs.

Career Changers

- Teachers entering the teaching force from a technical background should be offered the opportunity to pursue the MSSE to certify their credentials, and assure breadth of background knowledge in their discipline.

The remarks above about establishing communities of mathematicians at all levels apply equally well to scientists and science teachers, and the remarks about the content level for upper division and graduate science courses apply to all STEM courses.

APPENDIX B.

SAMPLE PROFESSIONAL DEVELOPMENT PROGRAMS

Sample Professional Development Opportunities for K-12 Teachers

Note: This is neither an inclusive listing nor an endorsement of any program cited.

Within Massachusetts:

Boston University

PROMYS for Teachers, <http://promys.bu.edu/pft>

STEM Pipeline, Immersion in Green Energy, <http://www.bu.edu/lernet/immersion>

Boston Museum of Science

http://www.mos.org/eie/workshops_programs.php

Bridgewater State College

http://www.bridgew.edu/Catalog/BIOE_BIOF_BIOL.pdf

http://www.bridgew.edu/Catalog/MATC_MATH.pdf

<http://www.bridgew.edu/Catalog/PHSC.pdf>

<http://www.bridgew.edu/Catalog/GSCI.pdf>

Department of Elementary and Secondary Education

Professional Development Institutes,

<http://www.doe.mass.edu/frameworks/cinstitute/08/default.html>

Mathematics and Science Partnerships,

<http://www.doe.mass.edu/omste/msp/fy08projectsum.html>

EDC (Education Development Center) On-Line and Distant Learning Opportunities

<http://www.cse.edc.org/products/onlinepd/colleges.asp>

EduTron

<http://www.edutron.com>

The ESE/Intel Mathematics Initiative (MIMI)

<http://www.doe.mass.edu/omste/news07/mimi.html>

Framingham State College

http://www.christa.org/main_page.htm

Massachusetts State Science & Engineering Fair, Inc. (MSSEF)
<http://www.scifair.com>

Museum Institute for Teaching Science
http://www.mits.org/k-8_teachers.htm

Northeastern University
Center for STEM Education, [http:// www.stem.neu.edu](http://www.stem.neu.edu)
Boston Science Partnership (with UMass Boston), [http:// www.bostonscience.org](http://www.bostonscience.org)
The North Shore Science Partnership (NSSP), <http://www.northshore.neu>

PV STEMNET: Pioneer Valley PreK-16 Science, Technology, Engineering and Mathematics (STEM)
Education "Pipeline" Regional Network
<http://k12s.phast.umass.edu/pvnet/>

Summer Math for Teachers
<http://www.mtholyoke.edu/proj/smt/index.html>

UMass Boston
Boston Science Partnership (with Northeastern), <http://www.bostonscience.org>

UMass Dartmouth Center for Community University, School and Community Partnerships
<http://www.umassd.edu/cusp/courses.cfm>
<http://www.umassd.edu/cusp/bbwp/bbwpprof.cfm>

Outside of Massachusetts:

The Algebra Initiative
<http://www.math.uic.edu/ome/alginit.html>

Lawrence Hall of Science Professional Development Programs
<http://www.lhs.berkeley.edu/profdev/programs.html>

Murray State College, College of Education, Professional Development Opportunities
<http://coekate.murraystate.edu/tes/>

The Park City Mathematics Institute for Secondary Teachers
<http://pcmi.ias.edu/>

Vermont Mathematics Initiative
<http://www.uvm.edu/~vmi/index.html>

University of Wisconsin On-Line Professional Development for K-12 Educators
<http://www.uwstout.edu/soe/profdev/>
<http://www.uwsp.edu/natres/msnree/online%20grad%20courses%200307.DOC>

University of Wisconsin, Madison: Wisconsin Teacher Enhancement Program

<http://www.wisc.edu/wistep/2008courses.html>

KEEP (K-12 Energy Education Program)

<http://www.uwsp.edu/cnr/WCEE/keep/ProfessionalDevelopment/index.htm>

Wisconsin Center for Environmental Education

<http://www.uwsp.edu/cnr/wcee/courses.htm>

College of Natural Resources

<http://www.uwsp.edu/natres/msnree/course%20descriptions%200406.doc>

APPENDIX C

REFERENCES

References for Part III, Item 3:

Ball, D.L., Ferrini-Mundy, J., Kilpatrick, J., Milgram, J., Schmid, Wilfried, & Schaar, R. (2005). Reaching for common ground in K-12 mathematics education. *Notices of the American Mathematical Society*, 52 (9), 1055-1058.

Ball, D. L., Hill, H.C, & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator*.

Hill, H.C., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, 42 (2), 371- 406.

Campbell, P. F., & Silver, E. A. (1999). *Teaching and learning mathematics in poor communities*. Reston, VA: NCTM.

Characteristics of a Standards-Based Mathematics Classroom

http://www.doe.mass.edu/omste/news07/mathclass_char.pdf

An Effective Standards-Based K-12 Science and Technology/Engineering Classroom

http://www.doe.mass.edu/omste/news07/scitechclass_char.pdf

Reference for a Discussion of Teacher Leaders:

Addendum 2, *Teacher Leader Concept* in Annual Report to the Board of Education, Mathematics and Science Advisory Council, 2006-2007

Research on Professional Development for Teachers:

Wisconsin Center for Educational Research, University of Wisconsin, Department Of Education
Teacher Research Spurs Professional Development:

http://www.wcer.wisc.edu/news/coverStories/teaching_research_spurs_pro_dev.php

National Institute for Science Education Report: Principles of Effective Professional Development for Mathematics and Science Education: A Synthesis of Standards:

http://www.wcer.wisc.edu/archive/nise/Publications/Briefs/NISE_Brief_Vol_1_No_1.pdf

All of their briefs available in PDF:

http://www.wcer.wisc.edu/archive/nise/About_NISE/NISE_Brochure/Professional_Development1.html

Research on Effective Professional Development with Annotations:

AERA. (Summer 2005) Teaching Teachers: Professional Development To Improve Student Achievement. AERA Research Points: Washington, DC.

http://www.aera.net/uploadedFiles/Journals_and_Publications/Research_Points/RPSummer05.pdf

PD research indicates need for school districts to use systematic methods for “evaluating the impact of PD on teachers’ practice and student learning”.

Foundations: Professional Development That Supports School Mathematics Reform.

<http://www.nsf.gov/pubs/2002/nsf02084/start.htm>

Brandford, J., Brown, A., & Cocking, R. (Eds). (2000) How People Learn. National Research Council: Washington, DC.

<http://www.nap.edu/html/howpeople1/>

Examination of research on learning indicating that optimum teacher learning occurs with learner-centered environments; consideration of prior knowledge, and preconceptions; transparency of PD rationale and expected outcomes; provision of feedback through formative assessment; and expectation for self-evaluation and self-monitoring of changing practice.

Banilower Eric R., Boyd, Sally E., Pasley, Joan D. & Weiss, Iris R. (2006). Lessons from a Decade of Mathematics and Science Reform: A Capstone Report for the Local Systemic Change through Teacher Enhancement Initiative. Horizon Research Inc/ NSF: Washington, DC.

<http://www.pdmathsci.net/reports/capstone.pdf>

Data from NSF Local Systemic Change (LSC) program for mathematics and science instruction outlines aspects of effective PD:

- Instruction improves in relation to teachers’ PD contact hours; however, PD over 80 hours provided limited increase in impact.
- PD needs to provide opportunities for teachers to work directly with high-quality instructional materials through “practice, investigation, problem-solving, and discussion”
- PD is supported over time with building capacity and infrastructure among stakeholders and policy-makers
- The quality of PD is sustained with the preparation and support of PD providers
- PD needs to deepen teachers’ content knowledge
- PD is maintained when teachers are provided with “ongoing individual and small group support”
- Outcomes are increased with stable and sustained administrative engagement and support
- PD planning must consider the implications of teacher turnover and build in incentives to increase participation

The Council of Chief State School Officers. (2008) Does Professional Development Have Effects on Teaching and Learning? Evaluation Findings from 14 States. CCSSO: Washington, DC.
http://www.ccsso.org/content/pdfs/cross-state_study_rpt_final.pdf

Report includes data from Massachusetts programs: Coalition for Higher Standards Math Partnership Program - Lesley/Mass Insight (MA); EduTron (MA) Key findings include:

- * One-third of evaluation studies reported measurable effects of teacher professional development;
- * Significant effects of professional development programs for teachers of math and science were found when the programs include focus on content knowledge in the math and science subject areas plus training and follow-up on pedagogical content knowledge;
- * One-third of the programs reviewed had well-developed evaluations that produced findings with measurable effects on student achievement or change in instructional practices;
- * Smaller programs typically had to choose a few measures and methods of evaluation; and
- * Measurement of change in teaching practices in the classroom is a promising outcome worthy of further use and expansion to other PD studies.

Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., & Hewson, H. (2003). Designing professional development for teachers of science and mathematics. (2nd ed.). Thousand Oaks, CA: Corwin Press.

This handbook guides professional developers, administrators, and teacher leaders in design inglearning experiences for teachers that are directly linked to improving student learning. It offers a framework for planning professional development, summarizes key research, and introduces critical issues. Findings include that teacher/learner-centered environments need to provide an expanded range of opportunities for teacher learning that link to improved student learning, e.g., mentoring and coaching; immersion experiences; teacher research projects; teacher-directed study groups; lesson study, etc

Porter, Andrew C, Garet, Michael S, Desimone, Laura M, & Birman, Beatrice F, (Spring 2003)
Providing effective professional development: Lessons from the Eisenhower Program. Science Educator.
http://findarticles.com/p/articles/mi_qa4049/is_200304/ai_n9198764

This report documents a study that uses a national probability sample of 1,027 mathematics and science teachers to provide the first large-scale empirical comparison of effects of different characteristics of professional development on teachers' learning. Results indicate three core features of professional development activities that have significant effects on teachers' self-reported increases in knowledge and skills and changes in classroom practice: a) focus on content knowledge; b) opportunities for active learning; and c) coherence with other learning activities.