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ABSTRACT

This brief discusses some of the results and conclusions from the Professional Development Project of the National Institute for Science Education (NISE). The project was intended to explore whether the science, mathematics, and professional development communities share a common understanding of what professional learning experiences look like and how teacher development should be nurtured. A variety of standards and related materials were reviewed as part of the project, and a listing of those is included. Seven principles that are found in excellent professional development experiences for science and mathematics educators are presented. The principles include ideas related to a clear, well-defined image of effective classroom learning and teaching; providing teachers with opportunities to develop knowledge and skills and broaden their teaching approaches; using instructional methods to promote learning for adults which mirror the methods used with students; building or strengthening the learning community of science and mathematics teachers; preparing and supporting teachers to serve in leadership roles; providing links to other parts of the educational system; and making continuous assessment part of the professional development process. (DDR)

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

by
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Katherine Styles
Peter Hewson

NISE BRIEF

REPORTING ON ISSUES AND RESEARCH IN SCIENCE, MATHEMATICS, ENGINEERING, AND TECHNOLOGY EDUCATION

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

by Susan Loucks-Horsley, Katherine Stiles and Peter Hewson

School reformers are paying considerable attention to the role that effective professional development can play in improving the teaching of mathematics and science. Significant contributions on this question are represented in national and state efforts to develop standards to guide reform. Some national efforts, such as those by the National Council of Teachers of Mathematics and the National Research Council, come from those who are interested in improving particular subject matter, as well as teaching and assessment. Other groups, such as the National Staff Development Council, focus on professional development itself.

Despite addressing the question from separate perspectives and disciplines, the different materials we reviewed largely reflect a common vision of effective professional development.

The Professional Development Project of the National Institute for Science Education set out to explore whether the science, mathematics, and professional development communities share a common understanding of what effective professional learning experiences look like, and how teacher development should be nurtured. We examined a variety of standards and related materials (NOTE: The materials reviewed for this brief are listed on page 4).

A Common Vision

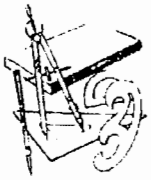
In fact, a great deal of consensus was noted. Despite addressing the question from separate perspectives and disciplines, the different materials we reviewed largely reflect a common vision of effective professional development.

According to that shared vision, the best professional development experiences for science and mathematics educators include the following seven principles:

1. They are driven by a clear, well-defined image of effective classroom learning and teaching. This image includes:

- A commitment to the concept that all children can and should learn science and mathematics.
- A sensitivity to the diverse learning needs of individuals and people of different cultures, languages, races, and gender.
- An emphasis on inquiry-based learning, problem-solving, student investigation and discovery, and application of knowledge.
- An approach to the understanding of mathematical and scientific knowledge and skills that helps students construct new understandings, through experiences that extend and challenge what they already know.
- Development of in-depth understanding of core concepts in science and mathematic, not just breadth of coverage
- Collaborative work.
- Clear outcomes, and assessment of progress toward them that accurately reflects meaningful achievement

2. They provide teachers with opportunities to develop knowledge and skills and broaden their teaching approaches, so they can create better learning opportunities for students. This process includes:



Teachers, like students, best learn science and mathematics by doing science and mathematics, by investigating for themselves and building their own understanding, as opposed to being required to memorize what is "already known."

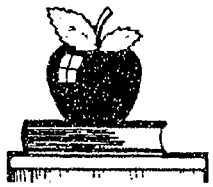
- Engaging teachers in learning experiences that enhance their understanding of major science and mathematics concepts and pedagogy. Teachers need deep, thorough knowledge of the disciplines they intend to teach.
- Strengthening teachers' knowledge of how children learn. While deep, thorough knowledge of mathematics and science is very important for teachers, it's not enough. Good teachers also know how to listen to students' ideas and pose questions that move them further, to help them develop stronger concepts. This requires a solid grasp of how students learn, and how curriculum and instruction can be crafted to teach students effectively. Teachers need to know, for example, what difficulties students of a particular age might encounter in learning a new skill or concept, and what misconceptions they might hold. They also need to be prepared to help students overcome their difficulties and to unravel misconceptions. Educators refer to this combination as "pedagogical content knowledge."
- Enabling them to make informed decisions about curriculum content and implementation. Teachers need to learn how to integrate a set of learning experiences into a course of study, and how to create a culture of ongoing learning in their classrooms.

3. They use instructional methods to promote learning for adults which mirror the methods to be used with students. Good learning opportunities for teachers:

- Build on the teachers' current science and mathematics knowledge, skills, and attitudes. Teaching teachers means having a good sense of where they are starting from, by clarifying their initial conceptions about science and mathematics, so that enrichment activities will be appropriate for them.
- Allow teachers to construct their own knowledge through immersion in the scientific and mathematical processes. Teachers, like their students, best learn science and mathematics by doing science and mathematics, by investigating for themselves and building their own understanding, as opposed to being required to memorize knowledge that is "already known."
- Provide teachers with opportunities to work in collaborative teams, to engage in discourse about science, mathematics, teaching, and learning, and to observe the modeling of relevant, effective teaching strategies. Many teachers find themselves unable to teach in the ways that students learn best because they themselves have not experienced that type of learning. Teachers need experience with strategies such as scientific inquiry, mathematical discourse, and learning cooperatively if they are going to be able to use those strategies with their students.
- Give science and mathematics teachers adequate and ongoing opportunities to develop, practice, and reflect upon new knowledge and strategies. Deep learning takes time, and takes place over time.
- Plan and design for structured, continuous opportunities for follow-up. Professional development should provide science and mathematics teachers with a structure, and ongoing support, for reflecting on their learning, getting feedback on the changes they make, and continually analyzing and applying what they learn.
- Unify the set of learning experiences through a comprehensive plan. Professional development is often experienced as a patchwork of fragmented, one-time learning opportunities, with limited potential to truly impact teaching and learning. Effective programs unite those experiences through a set of goals, strategies, and support over time.

4. They build or strengthen the learning community of science and mathematics teachers. In an effective learning community:

- Collegiality and collaborative professional exchanges are valued and promoted. Too often, teaching is a lonely and insulated profession. Teachers need to support each other and enrich each other's work. The school or



Teachers need to know that no one expects them to have all the answers just because they're certified as science and/or mathematics teachers, and that trying multiple times before experiencing success is a part of learning.

department should, in turn, support that collaboration: for example, by encouraging science and mathematics teachers to work together, to observe and coach each other, to inquire together into questions of common interest, and to share what they learn from workshops, conferences, and other professional development opportunities they have attended elsewhere.

- Teachers are encouraged to take risks, and are provided opportunities for experimentation. They need to know that no one expects them to have all the answers just because they're certified as science and/or mathematics teachers, and that trying multiple times before experiencing success is a part of learning. They need to feel they are supported in stretching their limits.
- Professional development is viewed as a lifelong process that is part of the school norms and culture. Schools should support the idea that everyone is always engaged in learning, not just students, and that asking good questions is at least as important as knowing the answers.

5. They prepare and support teachers to serve in leadership roles if they are inclined to do so. As teachers master the skills of their profession, they need to be encouraged to step beyond their classrooms and play roles in the development of the whole school and beyond. Leadership support includes:

- Planning and implementing professional development opportunities for themselves and others. Teachers should be key players in shaping that process, not just the targets of professional development activities.
- Acting as agents of change. Everyone within a school should be thinking about, and working for, reform. The school's culture should reflect an expectation that teachers will take on that broader mission. Teachers should have opportunities to learn the knowledge and skills they will need to be change agents, so they can work confidently and competently with others in all settings.
- Promoting a shared vision of science and mathematics education. Mathematics and science teachers must continually ask: What is the function of this experience in the broader context of a child's education? Is there a common understanding about the value of the experience by the child, parents, and other teachers and community members? How can I best promote a common understanding of the purpose of science and mathematics education?
- Supporting other teachers. Schools, districts and other organizations can create formal roles for teachers as mentors, coaches, lead teachers, study group facilitators, and resource teachers, and can prepare and encourage teachers to assume those roles by providing materials, staff development time, and other resources. These organizations also can encourage teachers to support each other in less formal ways, by engendering an atmosphere of cooperation and providing time for them to work together.

6. They consciously provide links to other parts of the educational system, by:

- Integrating professional development activities into other initiatives of the school or district. If, for example, a school adopts a new set of science materials, the school needs to decide what professional development experiences, supplemental materials, and other support teachers will need in order to make them work.
- Aligning activities with curriculum frameworks, academic standards, and assessment. Professional development can help teachers understand and apply the standards and initiatives that come to them from other levels of the education system. Teachers can thereby make the most of the opportunities the new standards provide.
- Establishing active support within the school, district, and community. Professional development, like teaching itself, cannot take place within a vacuum. Administrators, parents, and community members need to be aware of professional development activities for teachers, and to be provided with clear channels for providing input and assistance to teachers whenever possible and appropriate.

7. They include continuous assessment. Professional development programs must constantly be reviewed in order to:

- Determine participant satisfaction and engagement, and to make short-term adjustments. In the same way that continuous formative assessment is imperative in science and mathematics classrooms, monitoring teacher experiences in professional development provides opportunities to constantly improve the impact of these activities.

Standards and Related Resources Reviewed for this Synthesis

Standards

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1992). *Curriculum and evaluation standards for school mathematics.* (5th ed.). Reston, VA: Author.

National Research Council. (1995). *National science education standards.* Washington, DC: National Academy Press.

National Staff Development Council. (1995). *Standards for staff development–study guide: Elementary school edition.* Oxford, OH: Author.

National Staff Development Council. (1995). *Standards for staff development–study guide: High school edition.* Oxford, OH: Author.

National Staff Development Council. (1995). *Standards for staff development–study guide: Middle level edition.* Oxford, OH: Author.

Related Resources

Corcoran, T. B. (1995, June). *Helping teachers teach well: Transforming professional development* (Policy Brief No. RB-16). New Brunswick, NJ: Rutgers, the State University of New Jersey, Consortium for Policy Research in Education.

Loucks-Horsley, S., Brooks, J. G., Carlson, M. O., Kuerbis, P. J., Marsh, D. D., & Padilla, M. J. (1990). *Developing and supporting teachers for science education in the middle years.* Andover, MA: National Center for Improving Science Education.

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Loucks-Horsley, S., Kapitan, R., Carlson, M. O., Kuerbis, P. J., Clark, R. C., Melle, G. M., Sachse, T. P., & Walton, E. (1990). *Elementary school science for the '90s.* Andover, MA: The NETWORK, Inc.

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U.S. Department of Education. (1995). *Building bridges: The mission and principles of professional development.* Washington, DC: Author.

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Peter Hewson is a professor of science education at the University of Wisconsin-Madison. His research focuses on the learning and teaching of science and the education of preservice and inservice teachers.

Effective professional development means building a culture of ongoing learning for the adults in a school as well as the students.

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- Evaluate the longer-term impact on teacher effectiveness, student learning, leadership, and the school community. Too many resources are invested in professional development to ignore its impact over time. Identifying the full range of outcomes intended for professional development, and then exploring the extent to which these are achieved, can contribute to the knowledge base on professional development and improve its design and implementation.

Policy Recommendations

To support this vision of effective professional development, policymakers should consider the following issues:

- Using these principles to determine which professional development efforts should be supported and funded. For example, the principles can be used as criteria for Eisenhower-funded initiatives, school-based or district-based improvement projects, or plans for implementing technology. Plans that extend over time and go beyond workshops and institutes could be given priority.
- Improving preservice education programs for science and mathematics teachers, to model the principles of effective teaching and learning. Coursework at colleges and universities, especially content courses in science and mathematics, could model the kind of teaching that teachers are expected to pursue with their students. Preservice programs for administrators also could change, to help participants learn to build and sustain cultures of learning for the adults in schools as well as the students.
- Revamping recertification of teachers. Recertification could depend less on the amount of "seat-time" teachers log in courses and inservice programs. Instead, science and mathematics teachers could be encouraged to pursue more meaningful learning opportunities, such as periodically taking time away from teaching to perform scientific research. Teachers also could receive credit for such activities as peer coaching, participation in support groups, and engagement in professional networks.
- Creating time for professional development. Teachers need regular, scheduled blocks of time for working and learning together. It could be considered legitimate for teachers to spend time away from students and performing these activities. This can be aided by attention to scheduling, staff assignments, and time allocations.
- Requiring people and work units responsible for curriculum or content issues to work closely with those who are responsible for professional development. These two areas of responsibility, which today are often funded and considered separately, must be seen as inexorably linked.
- Building an infrastructure that supports ongoing learning. This could include the

Just as continuous formative assessment is imperative in science and mathematics classrooms, monitoring teacher experiences in professional development provides opportunities to constantly improve them.

A Synthesis of Standards
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creation of additional roles for teachers as providers of mutual support, developers of curriculum and professional standards, and developers of licensing procedures. Teachers also could be active participants in major projects, such as developing and scoring assessments and portfolios. These new roles for teachers could be created at the school level as well as statewide and nationally.

- Modeling effective learning environments. Those who make and oversee policy have special opportunities to inform people on issues, stimulate change, and monitor the impact of changes made. These public figures could emulate effective teaching and learning strategies by actively engaging people in learning over time, providing the public with different kinds of support for that learning process, and by seeking to capture the deepening and broadening impact of their work. They can, in effect, "walk their talk."
- Requiring a strong evaluation component in professional development efforts, including examination of both short-term and long-term impact. Are educators satisfied with their professional development experiences? Are they acquiring new knowledge and skills, and changing their practice based on those experiences? Are their organizations, by virtue of more collaborative cultures, better able to meet new challenges, and to implement and sustain changes? Are students learning mathematics and science better as a result? ❖

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