

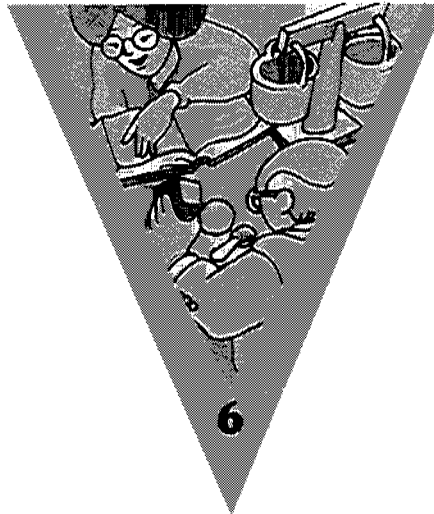
# *Science for All Children*



**A Guide to  
Improving Elementary  
Science Education  
in Your School District**

**NATIONAL SCIENCE RESOURCES CENTER  
NATIONAL ACADEMY OF SCIENCES • SMITHSONIAN INSTITUTION**

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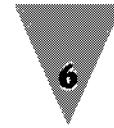


## **Professional Development for Inquiry-Centered Science**

*If teachers are given choices—are allowed to make decisions—are, in short, treated as both professionals and human beings—better teaching and better programs result. . . . When teachers are not “locked” into programs—are not tied into textbook-structured courses of study—their classrooms are alive and stimulating.*

— Ronald B. Jackson, *Something of Value*, 1973

**W**ith the curriculum selection process under way, it is time for the district to begin to organize the professional development component of the program. The initial goal of professional development is to introduce teachers to inquiry-centered science teaching and familiarize them with the specific science modules they will be teaching. This can be accomplished most effectively by creating a collegial environment in which teachers feel comfortable sharing ideas and working closely with experienced teachers.



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These don't sound like revolutionary ideas, but in fact they challenge some basic premises on which the American public school system is based. Traditionally, teachers have been assigned a classroom and have taught their students alone, conferring with few people and making their own decisions about how to implement the curriculum. Many teachers have become accustomed to this autonomy, and some even equate it with professionalism.

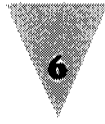
Carl Glickman calls this situation the "one-room school" syndrome, the tradition of isolationism created back in the days when teachers literally worked alone in their schoolhouses without any contact with other teachers. This tradition has lingered, and it manifests itself in today's schools by the tendency not to "connect staff for purposes of sharing expertise, solving problems, and pursuing improvement."<sup>1</sup> Given this context, a second, long-term goal of professional development is to foster the development of an environment in which teachers can learn and grow professionally.

This chapter discusses strategies that can be used to achieve these two goals. The chapter begins with a discussion of the characteristics of effective professional development programs for all teachers, from the novice to those in the "competent" stage to expert teachers. It concludes with a discussion of some strategies for professional development that have been successful in school districts throughout the country.

### **Characteristics of an Effective Professional Development Program**

The *National Science Education Standards* includes as part of its vision for science education reform increased opportunities for teachers to grow professionally throughout their careers. According to the *Standards*, "Teachers should have opportunities for structured reflection on their teaching practice with colleagues, for collaborative curriculum planning, and for active participation in professional teaching and scientific networks. The challenge of professional development for teachers is to create optimal collaborative learning situations in which the best sources of expertise are linked with the experiences and current needs of the teachers."<sup>2</sup>

Research and experience have shown that an effective way to introduce teachers to an inquiry-centered curriculum is to have



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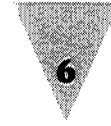
them experience each module in much the same way their students will. This approach is based on the assumption that the constructivist learning model is valid for adults as well as for children. Through the experience of working with the materials, discovering how the investigations build on one another, and encountering their own difficulties with the equipment or the concepts, teachers not only prepare themselves to teach the module but also realize that they can learn along with their students. Teachers who have made this discovery begin to rethink their role in the classroom and view themselves less as lecturers and more as learning facilitators.

The following list highlights strategies that have been effective in helping school districts create innovative professional development programs. These strategies will also help districts achieve the goals outlined in the *Standards*.

**1. Provide continuous and sustained support for professional development.** School district administrators need to send a clear message of support to teachers. The support must go beyond rhetoric and take the form of stressing science as a basic in the school curriculum and of providing teachers with a “safety net” so that they have time to grow professionally. Teachers should have the opportunity to experiment with different teaching strategies and to make mistakes without fear of consequences, with administrators recognizing that this is an essential part of their personal learning process. This learning process is not smooth, and nobody will become an expert overnight. Teachers need to have time to reflect on the new ideas that are being introduced and to assimilate them at their own pace. They also need to be aware that because science is considered a basic, they will be evaluated for their science teaching.

Other forms of support include providing teachers with the necessary materials on time, offering graduate credit for attending professional development classes, verbally praising teachers’ accomplishments, and publishing their achievements in school publications and the local media.

**2. Provide teachers with time to engage in professional development activities.** It is crucial that administrators recognize the key role teachers play in implementing a science program and give them the time they need to become proficient. This means granting teachers time to participate in professional development activ-



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ities during the school day. Unfortunately, given the way time is organized in the schools, this is no easy task.

Program directors and teachers need to be creative in the ways they address this issue. For example, teachers could use the time they have while their students are attending art, music, or physical education classes for their own professional development; arrange to have science when an experienced colleague could visit the class to assist; or invite parent volunteers to help with materials management so that the teacher has more time to devote to working with students on substantive issues. Other strategies include communicating electronically with other teachers to discuss science teaching strategies and encouraging students to assist with materials management so that the teacher can work with other students who have questions or need special help.

Teachers also have to be aware that involvement in the science program may require them to make additional time commitments. For example, they may need to attend summer institutes or after-school meetings. The incentive to give extra time will be greater if teachers see the administration working hard to make the school day more flexible to accommodate effective science instruction.

**3. Create an environment of collegiality and collaboration.** Teachers can benefit tremendously from professional relationships that enable them to feel comfortable sharing ideas, acknowledging difficulties, and solving problems they encounter in the classroom. Although a certain amount of discussion usually takes place informally among teachers, the best way to foster professional relationships is to institute some formal ways for teachers to interact. In formalizing such discussions, it is crucial that experienced teachers assume a leadership role. Discussions can wander unless leaders are present to facilitate them. One obvious way to formalize discussions is to address issues related to inquiry-centered science teaching at faculty meetings. For example, in Huntsville, Alabama, teachers found that their discussions during faculty meetings helped enhance relationships among teachers, making these meetings richer learning experiences.

Many districts have ensured that there will be opportunities for teachers to share experiences by scheduling at least two meetings each semester where they can discuss their progress in imple-

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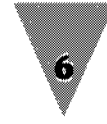
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*Teachers and a scientist (right) collaborate to construct a motor during a workshop on a sixth-grade module.*

menting inquiry-centered science modules. Such meetings help new or inexperienced teachers become more comfortable sharing problems and better able to accept guidance from their more experienced colleagues.

**4. Incorporate the change process into the professional development design.** In Chapter 4, we explained the stages that stakeholders typically go through as they become familiar with an innovation. Teachers undergo similar stages. For example, their initial reaction may be indifference to the innovation; this is followed by a concern about how it is going to affect them personally. As their familiarity with the program grows, teachers become more invested in the program and more interested in learning how to use it comfortably. At the final stage, teachers are concerned primarily with how the new program is affecting their students and with developing strategies to make the program even more effective.



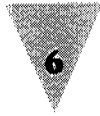
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Those responsible for designing the staff development program need to be aware of these stages and of the position of their teachers on the continuum of change. For example, if teachers in a particular district are at the “indifferent” stage, the emphasis of the professional development program should be on familiarizing them with the goals of inquiry-centered science. If teachers are concerned about who will be responsible for collecting the materials needed for the lessons, program designers need to address this issue and suggest how the materials will be provided and managed.

In most districts, teachers will be at different places along the continuum. Some teachers may already be comfortable teaching inquiry-centered science, while others may be afraid even to open the kit. In situations like this, districts may consider “pairing” a more experienced teacher with a less experienced one. This approach has been used in the East Baton Rouge Parish Public School System; experience there has shown that pairing increases the confidence and comfort level of the less experienced teacher.

**Initiating Professional Development at the Right Time in the Right Way**

Using the strategies mentioned above as a guide, the district must next consider when to begin the professional development program, who should be involved in the planning, and at what level of professional development to aim the program. The best time to develop a professional development program is usually during the six months before inquiry-centered modules are introduced in the district. As part of the professional development plan, the school district needs to determine how many schools are going to be phased in over a five-year period, and at what pace. Most districts have found that it is better to start with the teachers in a limited number of elementary schools and then to add more schools in each subsequent year. Depending on the size of the district, it takes between three and five years to introduce all the elementary school teachers in the district to all the science modules and for teachers to become reasonably comfortable teaching science through inquiry. In addition, fine-tuning pedagogical techniques, learning more science content, and integrating the science module with other areas of the



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curriculum are issues that need to be a continuing part of the teachers' lifelong professional development.

The time frame for introducing the professional development program is a complex issue related to the size of the district, the level of resources available, and the current capacity of the district. All these factors must be taken into consideration so that districts realize their long-term goal: to establish an effective, thoughtful, and comprehensive professional development program. Pressure to complete implementation should not interfere with realizing this goal.

It's also important to ensure that teachers become involved in the planning of the professional development program and that they become key players in the decision-making process. By making teachers partners in the planning process, administrators can go a long way toward building trust and creating a collegial atmosphere in which all participants acknowledge that they have much to learn from each other.

### **Levels of Professional Development**

In designing an effective professional development program, it's important to understand the phases that teachers typically undergo in their journey to become highly experienced elementary science teachers and the kinds of professional development programs appropriate for each phase. Research has shown that most teachers go through at least three phases: novice, competent, and expert.<sup>3</sup> The three programs described below are tailored for each of these phases.

#### ***Phase I: The Introductory Program***

An effective professional development program for novice teachers begins with an intensive introduction to inquiry-centered science, often in the form of a two- or four-week institute held the summer before the new curriculum is scheduled to be introduced in the classroom. At the institute, teachers become familiar with the science modules they will be teaching during the first six months (usually one or two modules) and discuss basic issues, such as managing the materials and organizing the lesson so that it can be completed in a timely fashion. In a relaxed setting with their





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peers, teachers can share common concerns, including the likelihood of increased noise in the classroom and how to relinquish a little control and let the children pursue their own interests during the science lesson. Teachers can help students pursue their own interests by providing them with opportunities to work independently. For some teachers, encouraging independent work may create a new set of challenges about how to maintain order in the classroom.

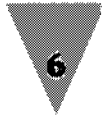
Teachers new to inquiry-centered science are especially concerned about classroom management issues such as these, because one of the greatest challenges of teaching science through inquiry is creating an environment conducive to interactive learning. How, many teachers wonder, does one create a setting where children feel challenged, eager to ask questions, and ready to explore their ideas with their classmates? Experienced teachers have found that establishing rules carefully is key; children must understand that they can talk but not shout, that accidents with the materials may happen but they should try to be careful, and that although they will be working independently or in groups, they must be prepared to listen to the teacher at appropriate times.

It's hard for many teachers to give up their traditional ideas of an orderly classroom. Consequently, even after attending an initial institute, teachers tend to revert to their old teaching strategies. They may be reluctant to divide the class into groups that are working independently. The first time they teach a module, they will probably rely heavily on the teacher's guide and skip many of the optional activities. These behaviors indicate that teachers are still learning how to use the materials and have not yet assimilated them and made them their own. This level of expertise is often referred to as *mechanical use*.

It's essential that teachers new to inquiry have support at their schools throughout the school year. Particularly beneficial at this stage are opportunities for mentoring sessions with more experienced teachers.

**Phase II: The Competent Stage**

When teachers begin to feel comfortable with the materials and are ready to modify the lessons in a science module to reflect their



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students' particular needs and interests, they are at the *competent stage*. It takes most teachers at least five years to reach this level of proficiency. At this stage, the professional development program takes on a different cast. Teachers are now interested in exploring in greater depth such topics as constructivist theory and the learning cycle, cooperative learning techniques, assessment strategies, and how to integrate science into other areas of the curriculum. Many teachers are also interested in learning more about the science content of the modules they are teaching. At this stage, the school should provide opportunities for small discussion groups for teachers engaged in teaching inquiry-centered science.

After being involved in these different professional development programs, teachers may begin to develop their own ideas for additional activities and extensions and look for other ways to modify the lessons. They may begin experimenting with different kinds of assessments and, if students are interested, with conducting a long-term class research project.

**Phase III: The Expert Stage**

The final phase in a teacher's professional development is the *expert stage*. If we could peek into a highly experienced teacher's science classroom, we would notice a few distinguishing features immediately. First, there is the sound of "organized noise" in the classroom. Children may be moving about, discussing ideas with classmates, and taking turns gathering materials at the distribution center. The teacher is moving around, too, listening to students' ideas, answering questions, and asking questions to help groups take the next step in completing an experiment or organizing results. By now, the teacher is not disturbed by the cup of water that spilled or the soil on the desktops. There is energy and excitement in the room.

Such teachers have become what is called "expert." They have reached this level through a combination of time, experience, their own enthusiasm, and effective professional development, both in the school and outside. According to the *National Science Education Standards*, "successful teachers are skilled observers of students, as well as knowledgeable about science and how it is learned. Teachers match their actions to the particular



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needs of the students, deciding when and how to guide—when to demand more rigorous grappling by the students, when to provide information, and when to connect students with other sources.”<sup>4</sup>

The goal of professional development is to raise all teachers in a school district to the expert level. Doing so requires time, commitment, and energy on the part of both teachers and administrators. The next section explores a few strategies for professional development programs that have helped teachers grow professionally.

### **Strategies for Change**

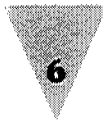
The professional development strategies listed below have been used in many school districts throughout the country. These strategies have been tested in a variety of settings and have proven to be effective in introducing large numbers of teachers to inquiry-centered science.

#### **Lead Teachers**

Many districts have initiated their professional development programs by beginning with a small group of teachers, called *lead teachers* or *mentor teachers*, who have demonstrated interest and expertise in inquiry-centered science teaching. This group is usually selected by administrators to represent each grade level in the district. Identifying and training this group of lead teachers is a key step in this professional development strategy.

Lead teachers can serve a variety of roles. In some districts, such as Montgomery County, Maryland, and the East Baton Rouge Parish Public School System in Louisiana, a cadre of lead teachers is responsible for conducting professional development activities for other teachers in the district. Those teachers also assist with materials support issues and are available to respond to questions that other teachers have about the program. Some hold workshops at faculty meetings. Others provide leadership at districtwide institutes. Lead teachers may often be called upon to field-test new modules, serve on curriculum selection committees, work with administrators to expand or modify selected modules, or develop new approaches to student assessment.

Although the lead-teacher strategy has been successful in many districts, some teachers and administrators have encoun-



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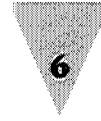
tered obstacles in their efforts to implement it. For example, in Huntsville, Alabama, teachers liked being introduced to the modules by fellow teachers, but they did not want to view a fellow teacher as a supervisor. In addition, some administrators have been unable to provide lead teachers with the time to actually “lead.” These teachers find themselves so busy with their own classroom responsibilities that they don’t have time to work with other teachers. Without time to mentor other teachers, lead teachers can serve only a limited function.

Schools nationwide are encountering the problem of teachers not having time for professional development. Time will continue to be an issue in a climate of budget cutting, especially in communities where parents exert pressure on the system to limit the number of professional days for teachers. Administrators and lead teachers committed to this approach must be aware that they will be grappling with such issues as they strive to implement the science program.

***Partnerships Between School Districts and Research Scientists***

In the 1960s, scientists’ involvement in professional development consisted largely of having scientists go into the classroom and take over the science class for a specified number of lessons. To no one’s surprise, teachers felt intimidated by the scientists, and the scientists often didn’t know how to present their subject so that it made sense to their young audiences.

To overcome these concerns while still taking advantage of scientists’ expertise, many districts have developed innovative forms of teacher-scientist collaborations. For example, the Pasadena Unified School District Science Program (formerly known as Project SEED), a teacher-scientist partnership between the Pasadena Unified School District and the California Institute of Technology (CalTech), has perfected a strategy in which lead teachers work collaboratively with scientists to introduce teachers to science curriculum modules. Scientists also conduct sessions with lead teachers at institutes, where the scientists serve as content specialists or in an advisory role, suggesting ways to bring inquiry to the classroom. CalTech scientists also attend follow-up meetings with teachers, where they are available to answer questions teachers



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have after working with the modules. This collaborative approach has also been adopted by City Science, a partnership between the San Francisco Unified School District and the University of California at San Francisco.

Some districts, such as Montgomery County, Maryland, have provided the scientists with some training before they begin their work with elementary school teachers. In a preliminary meeting, scientists learn about the concerns of teachers and some pedagogical strategies. This training gives scientists important background knowledge about teachers, so it becomes easier for the scientists to provide appropriate support and knowledge.

Scientists at other institutions, such as science museums, can work with teachers in a similar way. For example, the Buffalo Museum of Science in New York has a partnership with the Buffalo School District, where scientists are involved in professional development activities and in establishing a centralized science materials support center. The Franklin Institute, in Philadelphia, played a key role in introducing Philadelphia's public schools to inquiry-centered science.

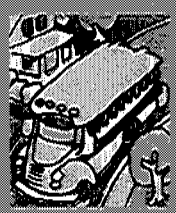
***Partnerships with Business and Industry***

Successful partnerships can develop between school districts and local industrial corporations. These corporations frequently have expertise that can be shared with teachers. Some corporate sponsors, such as Hewlett-Packard, have created on-line computer networks to answer teachers' questions about the particular topics their classes are investigating. Chapter 9 explores school partnerships with business and industry in more detail.

Some school districts incorporate combinations of these models into their professional development programs. For example, Montgomery County, Maryland, and Spokane, Washington, use the lead-teacher approach but also make use of university scientists for some portions of the professional development program. Alternatively, a corporate partnership may assist lead teachers by providing them with expertise in a particular subject area. In these ways, school districts can modify these strategies to fit their needs.

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**Key Points**

Professional development is key to the success of the inquiry-centered science program. Creating an environment of collegiality and collaboration, providing teachers with the time to learn, and designing the program appropriately are among the strategies school districts have used to ensure that the professional development program is effective.

Progressive levels of professional development can be designed for teachers new to inquiry, for those at the intermediate stage, and for those who have reached the expert level.

Several strategies, including the lead-teacher strategy, partnerships between school districts and research scientists, and partnerships with business and industry, have been used successfully in school districts nationwide.

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