Recommendations for Offering Successful Professional Development Programs for Teachers

A. M. Sarquis
Center for Chemistry Education, Miami University Middletown, Middletown, OH 45042; *sarquiam@muohio.edu*

The teacher's role in quality science education is critical and complex. As the School Science Curriculum Conference (S_2C_2) states in *Improving Physical Science Instruction in Elementary Classrooms*, "the effective teacher is alternately and simultaneously a diagnostician, facilitator, innovator, model, decision-maker, experimenter, evaluator, guide, materials manager, and source of knowledge" (*1*). Professional development opportunities are critical in helping teachers fulfill these roles and maintain their enthusiasm. Professional development is also crucial because "teachers will be the representatives of the science community in their classrooms" (*2*), and teachers' knowledge and understanding will need to continually grow as the science community changes and evolves.

With the goal of empowering teachers to succeed in the classroom, particularly in teaching chemistry and the companion sciences, the Center for Chemistry Education (CCE) at Miami University (of Ohio) has conducted more than 200 teacher development programs under the umbrella of its Terrific Science Programs since 1986. These programs have directly reached more than 13,000 teachers. This article summarizes what we have learned during these 15 years with the hope that others can use this information in building their own programs.

The CCE model for teacher development includes nine key components, of which seven were listed as "best practices" according to the 1993 National Center for Improving Science Education (NCISE) model (*3*). Our key components include program administration, vision of the classroom, teacher development program activities, contribution of partnering scientists, follow-up, teacher leadership, program evaluation, materials development, and dissemination. The CCE model has been recognized by the Chemical Manufacturers Association as a Recommended Model Program, by the National Science Foundation's Project Kaleidoscope as a "Program That Works", and by the U.S. Department of Education as a State Model Program. The examples provided in this article are taken primarily from the following three CCE initiatives:

1. Teaching Science with TOYS (TOYS), established in 1986 with funding from the Ohio Board of Regents and the National Science Foundation, offers hands-on chemistry and physics activities for elementary and middle school teachers based on toys and other everyday play items.
2. Partners for Terrific Science (Partners), established in 1986 with funding from the Ohio Board of Regents, the U.S. Department of Education, and the National Science Foundation, offers industry-based, hands-on chemistry activities for middle and high school teachers.
3. Science Integration in Today's Elementary Schools (SITES), established in 1987 through Ohio Board of Regents funding, offers integrated literature-based lessons for primary teachers using hands-on physical science activities and multicultural children's fiction and informational books.

Program Administration

With the philosophy that we don't do things *for* teachers but rather *with* them, CCE conducts teacher enhancement efforts to help teachers gain the tools, resources, experiences, and continued support they need to deliver quality science education to all students. To help ensure the usefulness of these endeavors, we include teachers and administrators working side by side with stakeholders from all target groups (e.g., industrial and university scientists) in the development, administration, and implementation of our programs. This collaborative relationship is evident in the Principal Investigator teams who shape the development of proposals, the mentor teams who develop and teach curricula, and the advisory boards who guide our programs' efforts. Such collaborative structures create multilevel impact on (i) the program's central structure (in terms of financial and in-kind support), (ii) instructional delivery and facilities (via tours, equipment, and mentors), and (iii) support of participating teachers (both during and after the interaction). Participating teachers, for example, gain valuable insights from teacher leaders whose experiences directly parallel their own situations, and they build support networks with mentor teams and CCE staff that continue for years beyond the initial interactions. This structure can also translate into long-standing partnerships between teachers and industrial scientists and managers. Such relationships not only benefit the schools but also help professionals in industry gain a real understanding and appreciation for teachers' concerns, resulting in long-term support for their area schools as well as continued support of CCE programs and organizational goals.

Attaining a program administration of this nature is not difficult. It often involves simply inviting members and scheduling meetings when all can attend. Maintaining the relationships and structure requires attention, empowerment to accept and assume responsibility, and accountability by all.

Vision of the Classroom

Imagine a classroom where students are actively engaged in discovering the fun and excitement of doing and learning science. This vision has become a reality in the classrooms of our program graduates around the country. Our teacher enhancement efforts emphasize and model interactive experiences that balance content with process and utilize student- and teacher-friendly materials such as toys, novelties, books, and other common household materials as tools to do and learn science. Our participants are also empowered to break down "the artificial barriers of subjects as individual units locked into specific time frames" (*4*). While our SITES program focuses on integrating science and language arts learning, cross-curricular integration of science throughout the entire curriculum not only provides relevance to students but also helps teachers alleviate the crunch on their instructional time.

An aspect of this vision of the classroom that is easily overlooked is the involvement of parents and other family members in students' science education, particularly at the elementary level. As Erich Zeller, a teacher in the Los Angeles Unified School District and a TOYS graduate, put it, "If you give the parents a little understanding about science and the inquiry process, you have sown the seeds for improved family relations with great home pedagogy! Voila, life-long learning" (Zeller, E. Personal communication, 1999).

Imparting the vision that "learning science is something students do, not something that is done to them" (*2*) to teachers in our programs is credited in part for the statistically significant increases in cognitive scores of students of graduates (*5*). We believe that understanding and articulating the vision of the classrooms and district culture we seek to achieve makes the planning and implementation easier for all parties involved. Building this vision is itself an ever-evolving process that can be enhanced through classroom visits as well as formal and informal interactions with teachers and administrators.

Engaging Teachers

We follow the National Research Council's recommendations that professional development activities engage teachers in active learning so that they build knowledge, understanding, and ability (*2*). In our efforts, we address what all experienced teachers know—that no single instructional strategy best meets the needs of all students (whether children or adults) at all times. By realizing that most students are best served when disciplines are presented and assessed in a number of ways, mentor teams are able to offer a diversity of entry points toward understanding (*6*). We apply and model a range of strategies we hope teachers will subsequently use in their classes, including activity-based instruction, guided and open inquiry, story-line- or scenario-based laboratory investigations, cooperative learning, and learning cycles. Workshops typically include time for teachers to experiment under the guidance of the course mentors as well as time to discuss pedagogy and other topics of interest to teachers.

We have also found that effective program scheduling and shaping of course expectations can facilitate integration of both methodologies and materials into the teacher's own teaching repertoire. For academic-year programs held over several months, we have found that assignments to use program materials with students and regularly discuss results with mentor staff provide teachers with practice and reinforcement of concepts and pedagogy. To provide similar feedback for the summer courses, we concurrently hold student science camps to allow teachers to try out program materials with children and provide campers with fun, exciting science while interacting with teachers from throughout the country. Since some teachers do not want to work with children outside of the school year, we inform participants before they come about the expectations and allow them to drop out if they object. More importantly, we make the interactions meaningful for both groups, and the courses are much more than baby-sitting periods.

All courses require participants to complete final projects in which they develop their own lessons based on course materials, use these lessons in their classrooms, refine them, and present them at both poster and oral sessions held during a follow-up meeting. We have found that basing credit, stipends, and grades on the completion of all program requirements, including these final projects, provides accountability for meeting project goals of integrating project materials into the classes of our teachers.

We believe that our achievement of statistically significant decreases in barriers to doing interactive science as well as increases in the use of teaching strategies that support such interactive methods results from these program design strategies. Teachers report growth in their ability to explain how science experiments work, skills to teach science, and effectiveness in monitoring science experiments (*7*).

Involving Industrial Scientists

Industrial scientists provide a valuable and complementary perspective to our professional development instruction. Not only do they have cutting-edge knowledge and access to up-to-date equipment, but they also provide links to local industry, helping teachers bring local relevance to their instruction. In our Partners courses, we have found it particularly effective to use a mentor-team approach that includes an industrial scientist, a college educator, and a K–12 teacher. These mentor teams provide a breadth of perspective and experience that complements the teaching of industrial science by modeling the variety of ways in which science is used in everyday life.

Involving partnering scientists in professional development programs for teachers opens doors for teachers to acquire equipment, perform summer internships, match professional mentors with students, and gain other experiences that translate into rewarding experiences for their students and colleagues. In addition to technical expertise, industrial involvement can result in the cosponsorship of program cost and materials.

While our initial intent in involving industrial scientists in such activities was to benefit teachers and our program, we discovered that the benefits were actually threefold. Peter McCann, Director of Scientific Administration and the Scientific & Academic Liaison for Merrell Dow Research Institute said of the company's involvement in the Partners program, "Our scientists and staff have also learned a considerable amount about concerns of teachers; a bonus which we had not considered previously" (McCann, P. Personal communication, 1988).

If you're unsure of ways to get industrial scientists involved in your programs, we recommend using contacts made in your local ACS section. While using established contacts including friends of friends typically provides quick payoffs, don't be afraid to make cold calls to area industry—including the human resource offices, laboratories, pilot plants, or operations—which often prove successful. The key to success in this area is to be prepared to move on a plan once a volunteer is identified. Empower your industry partners to take ownership of the effort while providing guidance and regular support.

Continued Follow-Up and Sustained Impact

Both formal and informal follow-up interactions have helped sustain our program impact over time by providing continued motivation and support and sustaining the creative momentum initiated during workshops. A longevity study of Partners graduates showed lasting improvements even after three years (*8*). Follow-up activities have included hosting return visits after graduates leave a particular workshop; making site visits to partnering schools; offering graduate academies and seminars at our site; supporting graduates' participation in programs at professional meetings; and using electronic and more traditional communication with graduates via newsletters, phone calls, listservs, etc.

You can also involve program graduates as guest presenters, teacher leaders, or mentors in future efforts, providing an invaluable resource to new participants. Additionally, try to assist graduates as they take on leadership roles within their districts. We have found that effecting sustained programming efforts, both in the district and for the individual teachers, requires graduates to assume increased leadership and responsibility within their districts. Teacher leadership can also take the form of community involvement as graduates establish new alliances and partnerships with area industries and other businesses and as they develop other out-of-school programs.

Figure 1 summarizes the path of leadership development that we encourage our program graduates to follow. The narrowing of the figure indicates that not all teachers at each level choose to move to the next level, but we work to move as many teachers as possible up these ranks of leadership.

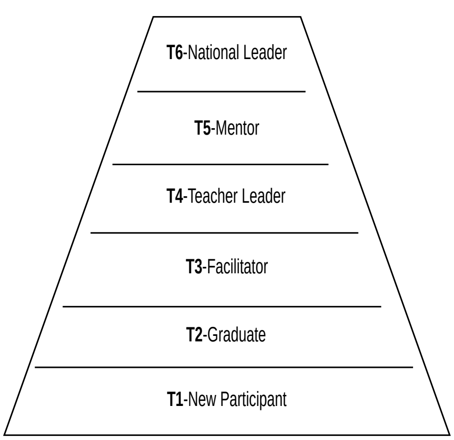

Figure 1. The leadership development path. T6: has very strong content and pedagogical knowledge, leads mentors and is a key part of instruction team, is involved in outreach and dissemination on a national level. T5: has very strong content and pedagogical knowledge, is a key part of instruction team, is a key contributor to materials development, is involved in outreach and dissemination on a state level. T4: has strong content and pedagogical knowledge, continues to test and implement materials in classroom, makes presentations, is involved in building and district level outreach. T3: second- and third-year graduate is expanding content and pedagogical knowledge, continues to test and implement materials in classroom, is involved in building and district level outreach. T2: first-year graduate develops content and pedagogical knowledge, tests and implements materials in classroom, shares informally with peers. T1: minimal content and pedagogical knowledge.

Through our programs, we have learned that forming teams of teachers and administrators from participating districts facilitates the development of district action plans to implement programs throughout the district. Evaluation of such efforts in TOYS shows participating districts undertaking a variety of methods to accomplish their plans. In addition to inservices for other teachers in the district, numerous other efforts have emerged, including reform of the curriculum, new funding for science, special programs for parents and families, and community efforts.

Program graduates who provide inservice opportunities to colleagues in their own districts can have far-reaching effects. For example, teachers attending inservices led by our Partners graduates had increased levels of comfort and confidence in leading Partners science activities with their own students; felt that they would not need more training before being able to do the workshop activities with their own students; felt that they understood more about various science teaching issues such as inquiry, learning cycles, and cross-curricular integration; and felt significantly more familiar with a variety of topics related to the chemical industry than before their participation (*9*).

Continuous Evaluation

Evaluation is necessary not only to provide documentation to funding agencies but also, more importantly, to provide a means of quality control. CCE uses a combination of focus groups and surveys typically given at entrance, exit, and six to eight months after completing the course. (We have found that phone surveys provide a much higher rate of return than mail surveys for follow-up.) This three-step survey method has proven quite useful, especially in showing that a statistically significant impact continues even after the official workshop has ended (*10*).

Remember, even if you hire an external evaluator, everything from getting the information to maintaining the quality of the program is your responsibility; therefore, you must be proactive. Evaluation can be very expensive, especially if research protocols are not set up correctly from the project's start. Interact with your project evaluator early (during project planning) and often. Be careful to clearly communicate your project and evaluation goals and your expectation of regular communication on both sides. Don't pay for services until they are rendered, and remember that the data collected is yours. Different institutions have different policies on work-for-hire—be sure you know and understand yours.

Curriculum Development

The National Research Council states that "participation in curriculum development, implementation, and evaluation is in itself a rich professional-development experience for teachers" (*11*). We believe that curriculum development is a natural extension of teacher professional development activities and is an opportunity for participants to integrate program materials into their own teaching environment. This component should be used in addition to the best practices of the NCISE model. Additionally, experimenting with and manipulating activities, especially in a laboratory setting, helps reinforce the nature of science. We routinely involve our participants in developing, testing, and revising activities developed through our programs. In addition to workshop testing, participants also classroom-test the activities with their students, providing revisions based on this classroom use.

Outreach

The intent of the CCE model for professional development that we've outlined here is to impact quality science education within districts as well as to arm participants with enthusiasm, confidence, knowledge, and tools to take back to their own districts; to provide them with the tools and support to effect quality science education in their districts; to prepare them to share what they have learned; and to provide them with the expectation and mechanism to multiply the impact many times over through outreach. Accomplishing this impact requires much advance planning, establishing district support and commitment before the outreach begins, troubleshooting during and after the event, and continuous support of graduates as they move into the district implementation domain. One of the key elements of our efforts in this regard has been advance commitment by district administrators. In order to be accepted, teacher applicants to our programs must procure signed agreements from their administrations to support their outreach efforts. Most programs also require a district contribution typically ranging from $100 to $400, depending on the number of contact hours provided. Most outreach activities done by our graduates are in the form of district inservices. We typically provide a modest allocation (approximately $100) to cover the cost of copying materials and providing supplies to participants in the inservices; districts are often required to provide matching funds.

Studies of our dissemination efforts show that a typical graduate reaches 30–35 additional teachers through outreach activities within two years of completing a CCE program. Additionally, we have shown through studies of these second-tier programs that program graduates who provide inservice opportunities to their colleagues in their own districts can have profound effects on teachers' comfort level with leadership. Oftentimes, teachers who attend these inservices need no or very little additional training before being able to do the workshop activities with their own students (*12*).

Conclusion

The rewards from a truly relevant and lasting impact on a teacher are boundless, because reaching even one teacher with the message that "Science is fun!" can lead to thousands of students developing and maintaining positive attitudes about science. Joe Lagowski of the University of Texas, editor of this *Journal* from 1979 to 1996, once said, "When you capture a teacher, you capture a generation" (Lagowski, J. Personal communication, 1979). We have found this to be true. As chemical educators, we are uniquely positioned to contribute to the achievements of scientific literacy by helping in the effort to improve professional development opportunities.

Professional development programs that adequately address program administration, vision of the classroom, teacher development program activities, contribution of partnering scientists, follow-up, teacher leadership, program evaluation, materials development, and dissemination can provide relevant and lasting impact on teachers. If you would like more detailed information about the CCE model or any of our programs, please contact the author or visit our Web site at *www.terrificscience.org.*

Acknowledgments

The programs referred to in this article were made possible by the following grants: TOYS (NSF grants TEI-8751244, TPE-9055448, and ESI-9355523 and OBOR grants 7-43, 8-37, and 9-38); Partners (OBOR grant 7-22, NSF grants TPE-8953362 and TPE-9153930, and U.S. DoEd grant R168A10068); and SITES (OBOR grants 2-60, 3-54, 4-45, 5-41, 6-30, and 7-42). I thank all the mentor teams and participating teachers who have made a difference in quality science instruction and gone on to influence generations of students. Thanks also to Amy Hudepohl, Document Production Manager in the Center for Chemistry Education, for her significant contribution to the preparation and writing of this article.

Literature Cited

1. *The School Science Curriculum Conference (S_2C_2): Improving Physical Science Instruction in Elementary Classrooms*; Sarquis, A. M.; Taylor, B. A. P., Co-directors; American Chemical Society: Washington, DC, 1992; p 13.
2. National Research Council. *National Science Education Standards: Observe, Interact, Change, Learn;* National Academy Press: Washington, DC, 1996; p 20.
3. *Profiling Teacher Development Programs: An Approach to Formative Evaluation*; The National Center for Improving Science Education; The NETWORK: Andover, MA, 1993.
4. Butzow, C. M.; Butzow, J. W. *Science through Children's Literature*; Teacher Ideas: Englewood, CO, 1989.
5. Haley-Oliphant, A. *TOYS Student Survey Pre and Post Test Data Analysis, School Year 1994–95*; Miami University: Oxford, OH, 1996.
6. Gardner, H. *The Unschooled Mind: How Children Think and How Teachers Should Teach*; BasicBooks: New York, 1991.
7. Seufert, R. L. *Partners Investigating Chemistry Together (PICT) Evaluation Report 1996*; Applied Research Center, Miami University Middletown: Middletown, OH, 1997.
8. Howe, S. R. *Partners for Terrific Science Evaluation Report*; Institute for Policy Research, University of Cincinnati: Cincinnati, OH, 1992.
9. Lakes Matyas, M. *Partners for Terrific Science Quantitative Evaluation Results*; Evaluation for Excellence: Olney, MD, 1995.
10. Seufert, R. L. *Summary of the SITES Evaluation: The Motz Attitudes Toward Science and Scientists Survey*; Applied Research Center, Miami University Middletown: Middletown, OH, 1998.
11. National Research Council. *The Role of Scientists in the Professional Development of Science Teachers*; National Academy of Sciences, 1996; *www.nap.edu/readingroom/books/role/* (accessed Feb 2001).
12. Matyas, M. L. *TOYS Final Report on Quantitative Data: Pre/Post Testing of Participants; Summer 1992 and Summer 1993*; Evaluation for Excellence: Olney, MD, 1995.