

Professional Development for Education-Engaged Scientists: A Research-Based Framework

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Abstract. New research findings from a study of scientists participating in education-related workshops reveal scientists' needs for professional development that can enhance their EPO work and help to sustain their involvement. (Last revised 9-07.)

1. Introduction

In his plenary talk (this volume), George Nelson argued that science teaching should strive to reach not just the 20% of students who can learn on their own, but all students in every lesson, every day. Likewise, he argued, professional development for K-12 teachers should target not just “space groupies,” but a much larger group of teachers not already attracted by the subject matter itself. We make a parallel contention: To change the culture and practices of scientists' participation in EPO, we need to offer professional development not just for committed scientist-educators, but for the much larger group of scientists who will not make careers in EPO but can contribute productively and enthusiastically in numerous smaller ways. While the development of today's science EPO professionals has occurred largely through bootstrap approaches (Fraknoi 2005), we will need to find more deliberate and efficient means to prepare the broader community of scientists that we seek to engage in EPO.

Given today's context of increasing emphasis on science EPO, the need for professional development for scientist participants is more acute than ever before. For this group, intrinsic motivations remain important, such as the belief that public science literacy is important, a desire to “give back” to their own communities or support children's education, and interest in sharing their own enthusiasm for science (Andrews et al. 2005). Added to these in recent years, however, are pressures from U.S. research funders such as NASA (1996) and NSF (2003) for scientists to communicate the “broader impacts” of their research. Highlevel concerns about maintaining the numbers and diversity of the scientific and technical workforce have raised science education to greater public awareness, and national leaders have called for scientists' participation in

education (Alberts 1991; Bybee 1998; Colwell & Kelly 1999; Leshner 2007). In this context, effective participation in EPO becomes a professional expectation of scientists, not just a hobby—an expectation that requires specialized knowledge and skills but for which most scientists have not been trained.

In order to support scientists in meeting these new expectations, the ReSciPE Project—Resources for Scientists in Partnership with Education—has undertaken a two-pronged effort, taking action to address this problem but also seeking greater understanding of it. Our goals have been:

- To increase involvement and effectiveness of scientists participating in K-12 education,
- To draw scientists into further professional development for their EPO work,
- To identify knowledge, motivations, and needs of these scientists, and
- To understand how they respond to professional development opportunities.

To enhance scientists' participation and effectiveness, we have developed a traveling, introductory workshop on "Scientific Inquiry in the Classroom." In 2.5 years, 18 workshops have reached some 400 scientists and their EPO collaborators. We also developed the ReSciPE Book, a web-based collection of annotated resources that address common needs of scientists as they work with teachers and students. To better understand this group, we have taken advantage of our workshop participants as a study population. Our evaluation-with-research study has explored the readiness, response, and needs of scientists for professional development to support their education work. In this report, we summarize findings from this study, focusing on scientists' professional development (PD) needs. We present these findings in the form of a framework that can guide development of future PD offerings. As an example of how this framework can be used, we apply it to one professional development model, ReSciPE's own inquiry workshop. Our aim is to inspire and guide those who work with scientists to apply the framework in planning professional development for their own EPO collaborators.

2. Study Methods

The study drew on data from multiple sources: online pre-surveys conducted when participants registered for a workshop; immediate post-workshop surveys; semi-structured follow-up interviews; and observations of workshop facilitators. Only participants who provided informed consent for use of their pre/post-survey and interview data were included in the study. A total of 276 participants completed the pre-survey, and the number of matched, consented, pre/post surveys was 147. Thirty follow-up interviews were conducted by telephone several months after workshop participation. The interview transcripts and open-ended responses to survey questions were coded for thematic content and the frequency of occurrence of codes or code groups across the data set was tallied. Quantitative survey responses were analyzed with descriptive statistics, using t-tests to analyze group and pre/post differences.

All study samples were drawn from the population of about 350 scientists and science educators attending a half-day professional development workshop on “Scientific Inquiry in the Classroom” between December, 2004, and April, 2006. Overall, workshop participants were a diverse group, with 60% women and 9% underrepresented minorities. They represented working scientists (70%) and graduate students (18%), predominantly from doctoral institutions (36%) and government labs (21%). Importantly, 73% were already doing some EPO—most (66%) in organized programs—and 51% said they spent more than one day per month on EPO work. In general, demographics of the survey (n=147) and interview (n=30) respondents closely mirrored the overall population (n=276). The interview sample included 50% research scientists and equal numbers of men and women. More on the samples and methods, and a review of prior work, is found in Thiry, Laursen and Hunter (2007).

While only a subset of findings is presented here, the study examined both evaluation questions of interest to our team in refining our program and measuring its effectiveness, and research questions of general interest to the EPO community:

- What do participants know already and learn from the ReSciPE workshops?
- In what ways is the notion of inquiry helpful as a starting point?
- What were the lasting outcomes of the workshops, e.g. use of workshop ideas, pursuit of additional professional development, or other outcomes?
- What are the current activities of education-engaged scientists?
- What motivations and barriers influence their involvement in education?
- What are their professional development needs?

3. Research Findings: Scientists’ Professional Development Needs

Here we highlight evidence on scientists’ professional development (PD) needs from the interview data, though survey data offer confirmation. A total of 113 observations on PD needs were identified in the 30 interviews and categorized into six types:

1. Motivation to engage in professional development, constituting 5% of all observations;
2. Accessibility of training (13% of observations)
3. Knowledge and skills (29% of observations)
4. Applicability to own work (18% of observations)
5. Broad participation in training (14% of observations)
6. Support for involvement in outreach (21% of observations).

These six types of needs can be arranged progressively across three stages in time: Categories 1 and 2 describe needs that influence how scientists can be drawn into professional development experiences to support their EPO work. Categories 3, 4 and 5 address needs that must be addressed by the professional development experience itself: the content, audience, and connections to their own work that will foster a meaningful professional development opportunity. Category 6 identifies the follow-up support that is needed to deepen and sustain scientists' ongoing EPO work. We discuss each category briefly and outline the implications for EPO practitioners as they consider the PD needs of their scientist colleagues.

3.1. Need for Motivation to Participate

The research scientists and EPO professionals interviewed saw a need to increase scientists' motivation to participate in EPO activities, and to pursue professional development to do this well. For example, one speaker said, "I'd say the biggest problem is one of motivation. And talking about scientists... the motivation to go to workshops, learn something about inquiry, and try to use inquiry, is extremely low."¹ Without participation, professional development will have no impact. Thus, those planning PD for scientists need to consider local, disciplinary, and national factors that will motivate participation, and identify recruiting strategies to identify and pique interest among potential participants.

3.2. Need for Access to Professional Development Opportunities

Interviewees wanted more opportunities to learn about education but recognized that these could not demand extensive time commitments, at least initially, if they were to reach a wide array of participants. They felt training in EPO should be standard training for science graduate students, while conferences should provide ongoing opportunities.

Make [professional development] available. We get very little of it. ...It just has to be more available, I would say. And I don't know, this is next to impossible to do, but it needs to become part of the curriculum for masters and Ph.D. students. I think it would help tremendously if such a class was required in all colleges, and universities.

In addressing this need, professional developers will need to assess what form of PD will be most accessible for their intended audience. Structures may include a short workshop or intensive course (Morrow & Dusenberry 2004), seminar series, study group, video/teleconference, online tutorial, or one-on-one coaching. The location and timing should optimize access to the PD opportunity. Strategies may be adapted from those used with other professional groups (Loucks-Horsley et al. 2003) but should be customized to fit scientists' workplaces and cultures.

¹It is clear from context that many statements in the interviews about "inquiry" are, like this, references to science education in general. Such conflation is ascribed to the ReSciPE workshops' focus on inquiry (see Laursen 2006 for arguments supporting this choice of topic).

3.3. Needs for Knowledge and Skills

Needs related to the content of a PD experience were noted often, at 29% of all observations made by 47% of interviewees. Participants wanted to build their knowledge of “best practices” in education and become aware of the research base supporting such practices. They sought to develop their presentation and teaching skills. As one put it, “It’s always a benefit to me to learn about resources for scientists to use, and also to understand better what good teaching is all about.”

To address this need, professional developers will need to identify their goals for content and skills they wish participants to learn, and attitudes or beliefs to be influenced. They will need to consider how PD activities will address content goals, who will facilitate the PD experience, and what forms of presentation will be used.

3.4. Needs for Content that is Applicable to One’s Own Work

Respondents strongly stated their need for content that was readily applicable to their own EPO work. Experiential learning was one way to make content applicable, when PD offered the chance for participants to learn in the same manner as recommended for students. They also suggested several ideas to aid transfer to their own settings: resources and tips to apply in their own EPO activities; examples of activities in their own disciplines; and help in connecting with EPO programs that would make use of their expertise and interest at the level of involvement they desired, for example:

Providing tips and guidance for how [scientists] can be useful, and a guide... Give a heads-up of what ten-year-olds need, in terms of their educational level. ...If people don’t know about something, it can seem very over-whelming and too much of a task. And so, to make it [easier], give the guidelines on how they can do it.

Transfer of learning to a new setting is hard (Bransford et al. 1999)—as true for scientists as for students. Professional developers can use varied learning strategies to reach their audiences and select examples from familiar areas, or out-of-field examples to focus participants on the methods used rather than the content covered. Some PD experiences may directly prepare scientists to participate in a specific program, while others address broad issues that apply across many settings. The handbook by Franks et al. (2006) and the ReSciPE Book (2005) are two resources that attempt to communicate EPO information in a manner relevant to scientists.

3.5. Needs for Broad Participation in PD

Many respondents (57%) observed that scientists and educators need to collaborate in EPO and felt that such collaboration should likewise take place within professional development for EPO. They called for participation by educators in PD for scientists and had benefited from educators’ perspectives in their own PD experiences, including the ReSciPE workshops. One speaker advocated:

Getting scientists and teachers together... I think a lot of times they really sort of need to get together to understand, when they have a

mutual respect for each other, but they don't always really understand each other's needs, and thought processes. So actually getting them together would be useful. It's just like in inquiry-trying to do science the way scientists do it—and scientists may need to do education the way educators do it.

Professional developers should be inclusive in their thinking and consider potential benefits from involving educators as well as scientists, as well as differences in their needs that may be better addressed separately. Approaches that value the contributions and expertise of all, while recognizing differences in perspectives, will be most successful (Tanner, Chatman & Allen 2003; Bower 1996).

3.6. Needs for Follow-up Support

Respondents identified a number of needs for support following a professional development experience that could help them make use of new learning and encourage ongoing participation in EPO. Key among these was collegial support—networking with others involved in EPO, and mentoring by more experienced colleagues.

I think it's having somebody who does that kind of thing . . . to be available— that they could show me how others have done it, and then I can incorporate it into what I'm doing. 'Cause I'm kind of alone in this thing, and I'm trying to figure out, "What could I do?" that would make it better

Scientists wanted to be able to plug in to existing programs that would use their expertise and provide this support, and sought meaningful, visible support from institutional leaders for their efforts. Indeed, follow-up support may be the most difficult challenge faced by professional developers, as they consider how to foster community, link people with ongoing programs, sustain individual and institutional involvement, and engage leaders in recognizing and rewarding EPO involvement.

4. Applying the Framework in Practice

To gain experience with the framework and to test its utility, conference participants analyzed a case study, the ReSciPE Project's half-day workshop on "Scientific Inquiry in the Classroom." First they read a short description of the workshop, using a "jigsaw" approach to divide the reading and share information among group members. Then, for each of the six types of needs listed above, they considered what features of the workshop addressed this need and the extent to which this need was met by this particular workshop. This analysis demonstrated the use of the research framework in assessing the strengths and weaknesses of an existing PD opportunity to judge its effectiveness or to improve it. The results of this analysis are summarized in Table 1.

As for any real-world educational offering, it is impossible to meet every need expressed by every individual. Tradeoffs are inevitable as developers make

Table 1. Comparison of the Research Framework with a Real-World Case Study

<i>Research Framework: Scientist PD Needs & Contributing Factors</i>	<i>Case Study of ReSciPE “Scientific Inquiry” Workshop: Features that Address Scientist PD Needs</i>
1. Motivation to engage in PD - Personal, local, disciplinary & national context	Self-selected; 75% already engaged in EPO. NSF ‘Broader Impacts’, NASA EPO interests. On-site recruitment was personalized at labs.
2. Access - Format & length - Where, when, how many - Recruitment & visibility	Half-day workshops short enough for busy people. Go where scientists are: conferences & labs. Hosting societies helped with advertising. Hosting labs coordinated logistics & recruitment; off-site presenters helped make it a special event. Endorsed by local lab leaders. Diversity of attendees shows that access was broad.
3. Content - Knowledge - Skills - Beliefs - Presenters & presentation modes	Chose inquiry as introductory topic for all fields. Used mix of presentation modes & activities. Summarized evidence base on ‘How People Learn’. Targeted to novice level; not program specific. Offered conceptual framework but not ‘how-to’. Modest number of examples in any discipline. Data show learning gains, attitude changes.
4. Applicability to own EPO work - Relevance of content - Experiential learning - Chance to work on own projects	Linked student inquiry to scientific inquiry process. Presented by scientists & educators. Mix of activities supported varied learning modes. Brief opportunities to share work & apply; no extended personal planning time. Not tied to a specific EPO program.
5. Broad participation - Mix of participants - Involvement of educators - Network-building	Focused on scientists, with some teachers present. Mix of career stage, age, discipline. Chance to meet kindred souls interested in EPO. Discussion and social time included.
6. Follow-up support - More PD, coaching - Content-specific resources - EPO programs to join - Institutional visibility - Sustainable involvement	Offered online resources, email list-serv. At lab sites, local coordinators could follow up. At professional meetings, little follow-up provided to individual attendees from widespread institutions.

choices about their PD approaches and strategies. However, this empirical framework can help professional developers recognize those tradeoffs and make more informed and deliberate choices. For example, conference participants identified some of the tradeoffs evident in the ReSciPE half-day workshops:

Thorough vs. accessible: the choice to offer a half-day workshop made the workshop available to more participants, who were willing to commit a modest amount of time, but limited the opportunity to go into topics in depth.

Broad vs. disciplinary: the choice to offer a general, introductory workshop appropriate to scientists from many disciplines was balanced against scientists' desire to see examples from their own field that they could apply directly to their own work.

National vs. local: the choice to offer a traveling, nationwide workshop weighed against the opportunity for local follow-up, yet the "special event" nature of visiting presenters attracted participants who might not otherwise have attended.

With this background, participants then reflected on the framework as a tool for planning scientists' professional development to benefit their own EPO programs. "It certainly helped me organize my own thinking," said one participant. In adapting the general framework to their own setting, the role of local institutional factors became particularly evident in certain areas. Local initiatives and contexts were seen to influence scientists' motivations; the needs of local programs for scientists' expertise shaped the types of opportunities for scientists to participate and the skills and knowledge they would need to do so effectively; and potential collaborations were identified with other local programs that might wish to co-host professional development activities. Participants recognized that sharing of PD models from diverse EPO providers could help improve PD offerings more widely and increase the professionalism of scientists' EPO participation.

5. Conclusion

We have proposed a framework, based on empirical data, for addressing the professional development needs of scientists as they begin to engage in EPO. Analysis of one real-world case study in comparison to the framework shows that it is possible to design a professional development opportunity to meet many of these needs, but tradeoffs will inevitably arise. It is clear from this analysis that no single professional development model can meet all the needs of all education-engaged scientists. EPO leaders will need to provide a range of PD offerings to meet the needs of both novices and those plunging deeper into EPO, to address concepts that cut across fields as well as within disciplines, and to support specific EPO programs as well as address broad concerns. We offer this framework to assist professional developers in designing and evaluating such offerings.

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