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Feature Article

Teacher Professional Development and Informal Learning Environments: Investigating Partnerships and Possibilities

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To provide meaningful science experiences for students, educators need quality science experiences themselves from which to draw. Informal learning contexts, such as museums, are well positioned to provide educators with these professional development experiences. We investigated the impact museum-created professional development experiences had on 54 elementary teachers. Quantitative data were collected through an exit survey and qualitative data through survey questions and interviews. We found a significant difference between how teachers rated these workshops and how they rated other workshops. Teachers reported that the workshops helped them to (a) increase science content knowledge, (b) understand the process of science-scientific fieldwork, (c) change instructional methods, (d) connect natural science content with formal instruction, and (e) learn about museum resources for the classroom.

Introduction

Research related to science learning in informal contexts often focuses on families, students, and adult visitors (e.g., Ash, 2003; Borun, Chambers, & Cleghorn, 1996; Cox-Petersen, Marsh, Kisiel, & Melber, 2003; Falk & Dierking, 1997; Griffin & Symington, 1997; Melber, 2003). However, the number of studies assessing the impact of teacher professional development in these settings is limited. The purpose of this study was to inquire into the impact of three different models of professional development workshops offered by a large natural history museum. These three models included (a) Model A, a museum-based professional development; (b) Model B, a museum and field-based professional development; and (c) Model C, a field-based professional development. Each model was designed, organized, and taught by museum education professionals. All workshops provided the opportunity for teachers to communicate and practice scientific inquiry with museum scientists, enrich their scientific content knowledge, and develop inquiry-based science lessons aligned with the National Science Education Standards (National Research Council, 1996a).

Conceptual Framework

Our supporting framework was created through a review of recent research from several complementary fields. These included (a) professional development for teachers, (b) informal science environments as contexts for learning and teacher development, and (c) science education reform efforts and their recommendations about the use of informal learning environments to enhance understanding of science content and processes.

Professional Development

In this paper, we use professional development to describe any educational activity that attempts to help teachers improve instruction — specifically, science instruction. Each of the professional development programs reported here represented an integrated approach — combining content and instructional presentation with actual scientific specimens and views expressed by scientists through informal discussion. While other programs do provide this blend of content and pedagogy, many do not have the additional resources of practicing scientists and touchable artifacts and specimens from which to draw. Those programs differ even further from programs that introduce a new innovation, educational theory, or fine-tune a specific educational style or presentation. They align more closely with professional development as a process of empowerment (Gilbert, 1994) and transformation (Tippins, Nichols, & Tobin, 1993). For example, Howe and Stubbs (1996) described an empowering professional development program where teachers were given tools and the opportunity to construct knowledge and meaning in a supportive social environment, one sensitive to educators' strengths, as well as areas about which they may feel less confident, such as science. In those programs, the goal is for teachers to take charge of their own growth and development related to science instruction. Empowerment or transformational professional development programs shift the focus from teacher training, such as learning to parrot a particular curriculum word for word, to environments that promote teacher professionalism within a community of educators (Tippins et al., 1993), providing educators with the background to make educated decisions on instructional technique and curriculum delivery. This is echoed in the National Science Education Standards (National Research Council, 1996a), which specifically note the importance of providing opportunities for empowerment in their assertion that "the conventional view of professional development for teachers needs to shift from technical training for specific skills to opportunities for intellectual professional growth" (p. 58). For example, rather than simply memorizing how to do a hands-on, cookbook science activity step by step, learning the steps that constitute science inquiry so they can design their own activity around whatever topic is at the core of the curriculum. In considering what we know about best practices in professional development, a review by Garet, Porter, Desimone, Birman, & Yoon (2001) indicated that, among successful professional development programs in science and mathematics, common elements include (a) a focus on academic content, (b) opportunity for hands-on experiences and active learning, and (c) clear integration into classroom application, all elements present in the workshop models at the focus of this study.

Professional Development Within Informal Contexts

Informal science education is credited as playing an important role in engaging students in science experiences that differ from formal instruction (National Science Teachers Association, 1998). Consequently, in a report published by the National Science Foundation, it was found that 85% of people with science careers named visiting a science or natural history museum as one of their most memorable informal experiences as a child (Cosmos Corporation, 1998). Museum educators are continually encouraged to capitalize on the educational potential of museums to improve the quality of learning for students (Cox-Petersen et al., 2003; Gilbert & Priest, 1997). These environments provide virtually untapped potential to engage teachers in professional enhancement that integrates professionalism, content, and pedagogy. Although museums around the globe offer some type of professional development for teachers (e.g., National Science and Technology Museum, Kaoshiung, Taiwan; Denver Museum of Natural History; the American Museum of Natural History; and the Exploratorium of San Francisco), few of these programs report publicly the impact on teachers who have enrolled in their programs or discuss what types of informal environments have proven to be most successful for them.

Professional development programs within museums can take many forms. Some offer on-site programs that last anywhere from an afternoon to a collaboration lasting months. Moe, Coleman, Fink, and Krejs (2002) described a program at the Utah Museum of Natural History designed to help educators learn concepts in ethics and character related to scientific research and science teaching. Shields (2001) reviewed a number of ways that museums support "cross curricular learning" (p. 36) through technology, including a video conferencing program for educators offered through the Museum of Modern Art. McLeod and Kilpatrick (2001) posited that museums can offer professional development opportunities that address both science content and instructional strategies. They described a program at the Orlando Science Center in which teachers had extensive opportunities to work with museum educators in creating inquiry-based science experiences and to broaden their own understanding of effective instructional strategies.

The few researchers who have investigated teacher development within informal contexts have reported positive results. Neathery (1998) assessed learning of elementary teachers in three different informal environments: a science center, wildlife refuge, and a zoological sanctuary. She found these learning experiences greatly enhanced teachers' conceptual development and understanding. Falk and Drayton (1997) inquired into teachers who participated in a year-long research endeavor with local ecologists. They found that teachers' increased self-perceptions of their own scientific understanding resulted from their authentic practice of science and from the connections to the scientists' culture. Smith, McLaughlin, and Tunnicliffe (1998) compared trained and untrained teachers who accompanied their students on a zoo field trip and found that students with trained teachers learned more from the experience. Sukow (1990) found that teachers who participated in physical science workshops linked with science exhibits patterned after those at San Francisco's Exploratorium increased their confidence and competence in understanding science and delivering inquiry-based science instruction. These teachers continued to develop exhibit-like props to investigate scientific phenomena with their students. Each of these studies found that teacher participation in professional development workshops linked to informal learning contexts, such as museums, provided a wealth of unique resources and experiences that teachers could readily apply to science instruction.

Other researchers have reported findings of teachers and adults who participated in apprenticeships assisting scientists in a variety of laboratory and field settings. McComas, Cox-Petersen, and Erikson's (1999) qualitative findings indicated that most adults who participated in an Earthwatch Institute program gained a greater understanding and appreciation of the nature of science, and Eades (2002) provided a detailed description of an Earthwatch experience. However, Bell, Blair, Crawford, and Lederman (2003) found that "doing science" within an apprenticeship program did not improve graduate students' understanding of the nature of science and scientific inquiry as defined by the National Science Education Standards (National Research Council, 1996a). Participants learned isolated process skills, but did not learn much about how science is actually "done." Therefore, they recommend a systematic reflection of actions and experiences within apprenticeship programs and within teacher education programs. Miles (1991) agreed with Crawford and her colleagues (Bell et al., 2003), stating that educators should provide time for structured and organized reflection when taking individuals into natural areas as an educational experience. Overall, experiential learning opportunities, such as those offered within various scientific field sites, provide a lens through which teachers can examine authentic scientific investigation and apply their experiences to science teaching.

Science Education Reform Efforts

The content, pedagogy, and professional development elements within the workshops presented in this paper are aligned with the National Science Education Standards (National Research Council, 1996a) in the United States. The professional development standards specify that teachers should engage in ongoing opportunities to build their understanding of the rapidly changing knowledge of science. They should also learn essential science content through scientific inquiry and understand the nature of scientific inquiry as it relates to the generation of scientific knowledge. The teaching standards posit that "The classroom is a limited environment. The school science program must extend beyond the walls of the school to the resources of the community" (p. 45). Without professional development at such community and outdoor sites, teachers may not benefit from the educational potential of sites for themselves or their students.

Professional science education groups, such as the National Science Teachers Association (NSTA), further acknowledge the role that informal learning institutions can play in the professional development of science educators. In the position statement on informal science education, this teacher organization stated that "Informal science education institutions have a long history of providing staff development for teachers . . . . Informal science learning experiences offer teachers a powerful means to enhance both professional and personal development in science content knowledge and accessibility to unique resources" (National Science Teachers Association, 1998, p. 17).

Methodology

We inquired into the impact of three variations of professional development workshops using an explanatory case study approach (Yin, 1994). We investigated how these workshops enhanced elementary and secondary school teachers' understanding of science content, inquiry-based instructional practices, and museum resources and nature areas available within the community. The three workshop models were Model A, a museum-based professional development (southern California natural history); Model B, a museum and field-based professional development (entomology); and Model C, a field-based professional development (desert paleontology and ecology). Model A took place in three different locations; two workshops were held at natural history museums, and the other one was held at an automotive museum. Model B encompassed a full-day session at a natural history museum and a full-day session at a scientific field site. Model C was held entirely at a paleontological field site in California's Red Rock Canyon. First, each of the three models will be described. Next, the effects of workshop participation will be presented, both across cases and model specific. Lastly, limitations of the study will be discussed, together with conclusions that can be drawn from the presented data. The study is delimited to the three workshops, their content, specific teachers who participated, and the museum educators who conducted them.

Quantitative and qualitative data were collected using multiple instruments that included (a) an end-of-workshop questionnaire with Likert-type scale measures and open-ended response options, (b) an open-ended follow-up questionnaire completed at 4–6 months postparticipation, (c) semistructured teacher interviews conducted at 4–6 months postparticipation, and (d) an open-ended follow-up questionnaire completed at approximately 2 years postparticipation. Specifically, we inquired into

1. how field-based and museum professional development workshops compare to traditional teacher workshops;
2. how museum-based, field and museum-based, and field-based workshops compare to each other;
3. how working with museum scientists helps teachers understand specific science content and processes;
4. how field-based and museum workshops help teachers enhance science instruction (i.e., content, pedagogy, and curriculum knowledge); and
5. how field-based and museum workshops enhance teachers' awareness of museum and science field resources.

Participating teachers in this study attended at least one of the three informal environment workshops described previously. Attendance at the workshops was voluntary and conducted outside of traditional work hours. Model A, the museum-based workshop, had 19 elementary teachers, 1 secondary teacher, and 2 teachers who did not share grade level. Model B, the museum and field-based workshop, had 15 elementary teachers, 3 secondary teachers, and 2 teachers who did not report their grade levels participate. Model C, the field-based workshop, had 6 elementary teachers, 11 secondary teachers, and 1 teacher who did not report grade level participate. When participants for all three workshops were combined, 77% of the educators taught in urban areas, 19% taught in suburban areas, and about 4% of the participants indicated that they taught in rural schools.

Elementary (K–6) and secondary (7–12) teachers who participated in the workshops ($N = 60$) were asked to complete an end-of-workshop questionnaire. Only completed surveys were included in this study ($N = 54$). This survey was distributed on the last class session to gauge teachers' perception of the science content, inquiry-based instructional strategies, and the degree to which the workshop was regarded as valuable to professional development. Participants were asked to rank their perceived knowledge level, through retrospective analysis, of various content and pedagogical subjects both before and after the workshop. A random sample of teachers ($n = 12$) from each workshop was asked to answer questions via a telephone interview approximately 4–6 months after their participation. Semistructured interview questions focused on their understanding of scientific content, scientific inquiry, and the application of their experience into the classroom. A follow-up survey was mailed to participants who could not be contacted by phone. Survey questions were the same as those asked during the teacher interviews.

As a fourth data source, a final follow-up questionnaire was mailed to all the participants of the three workshops nearly 2 years after the workshops. Nineteen questionnaires were returned and, of those, 17 contained usable data (one described a nonmuseum workshop, and the other did not name the specific workshop). Data were analyzed quantitatively using Likert-type scale rankings and independent sample t-tests, with qualitative comments analyzed for additional support.

Quantitative data from end-of-workshop questionnaires were analyzed using descriptive statistics and paired t-tests to compare perceived knowledge, before and after participating in the workshops in the area of scientific content and process. An analysis of variance (ANOVA) was used to compare responses from each workshop. Qualitative data (open-ended survey questions, teacher interviews, and follow-up surveys) were analyzed by identifying trends within the data that related to science content, instructional strategies, and science resources.

Description of Three Professional Development Models

We investigated three different models of educator workshops held by natural history museums. Workshop Model A was primarily based in the museum; workshop Model B was comprised of 1 day in the museum and 1 day at a field site; and Model C was held completely at a field site. A number of elements were shared by the three workshops. The curriculum for each was designed by the same museum professional, and all workshops had museum educators as workshop leaders. Second, the overall length of each workshop was a total of 15 contact hours. Lastly, all three workshops included interaction with a museum scientist, though to different degrees, as indicated in the descriptions below.

Model A: Museum-Based Professional Development

This 3-day workshop was based entirely in museums. Sessions were held from 9:00 a.m. to 3:00 p.m. on alternating Saturdays at three different museums, all located in an urban area of southern California. Participants spent each day at a different facility: The first meeting took place at a small natural history museum dedicated to paleontological studies, the second at a large natural history museum, and the third at an automotive museum. The activities of the workshop focused on changes that have occurred in southern California beginning with the Ice Age and terminating with modern-day society and the influence of the automobile. Specific science concepts included paleontology during the first session, archaeology and anthropology during the second session, and topics in the physical sciences, such as Newton's laws, as they relate to transportation technology during the third session.

About half of the course had educators participating in hands-on activities and problem-solving sessions in a classroom setting and using museum objects and specimens. All activities were designed to be immediately implemented in a classroom environment with support from state frameworks that were intended to provide specific instructional strategies and guidance on teaching techniques. Participants were shown how to acquire artifacts and specimens (e.g., feathers, acorns, rocks) free of charge or, via the museum's loan service, to borrow more difficult to obtain artifacts or specimens. Self-guided exploration of the halls was also a significant part, approximately 40% of each workshop. In the first session, participants toured a paleontology laboratory and asked questions of a museum scientist. All participants received a packet of curricular materials to enhance transfer of the workshop concepts and activities into the classroom.

Model B: Museum and Field-Based Professional Development

This 2-day workshop consisted of 1 day held at a large natural history museum and 1 day at a local field site in the Santa Monica Mountains. Each workshop lasted from 8:00 a.m. until 5:00 p.m. and was led by two museum educators, one of whom had a strong entomological background. The entomologist joined the group in the field on the 2nd day. All participants received the field guide, "Insects of the Los Angeles Basin," as well as a packet of curricular materials to support classroom transfer of the workshop activities.

This workshop's combination approach included 1 full day devoted to hands-on activities and explorations within a museum and 1 full day devoted to fieldwork. While in the museum, participants toured the live insect zoo and created a terrarium of their own for use in the classroom. In addition, they explored various activity stations set up as a model for potential classroom activities. They also handled live insects that were part of the museum's traveling insect zoo. The 2nd day included a slide show by the museum entomologist on common insects of Los Angeles and then time to investigate hiking trails and identify many of these species in the field. Participants were given collecting devices, such as nets and small cups, and discussed discoveries with the entomologist to confirm identification of what they found. There were also activities on compass reading and harmlessly collecting insects in various habitats, such as a tree branch, a small pond, or under rocks.

Model C: Field-Based Professional Development

This 2-day workshop was based entirely in the field, specifically Red Rock Canyon State Park located in the Mojave Desert of California. The workshop was a weekend campout in which participants supplied their own tent and sleeping bag, but meals were prepared by a camp cook. A two-hour meeting was held a few days before departure to acquaint participants with background content about Red Rock Canyon and pretrip information related to workshop content and activities.

This workshop was comprised mostly of fossil hunting excursions and ornithological study walks conducted by museum scientists. A museum educator was also present to provide instruction on how these field experiences could translate into more authentic classroom activities to enhance student understanding of scientific research. In addition, participants received a packet of related materials and curricular connections to the content. Activities included locating and excavating fossil mammal specimens, field identification of desert wildlife, discussions of the surrounding geology, fossil casting, and bird identification using a spotting scope. The entire program was spent in the company of two paleontologists and one museum educator. A museum ornithologist was present for 1 of the 2 days.

Findings

Museum-Associated Workshops in Relation to Traditional Workshops

Cumulatively, we found a significant difference between how participants rated the museum workshops as opposed to most workshops they attend. Two questions that each of the surveys had in common asked participants to rank on a Likert-type scale of 1–5 (1 = *not at all* and 5 = *very*):

1. How helpful do you consider most workshops (not museum-sponsored) you attend?
2. How helpful was this workshop?

These responses were combined and a paired-samples *t*-test run to compare the mean rank for each question to determine if participants ranked the museum-sponsored workshops as significantly more helpful. Participants of all three models ranked the workshop they had attended in association with the museum significantly higher ($M = 4.50, SD = .575$) than "most" (nonmuseum affiliated) workshops they have attended ($M = 3.70, SD = .964, t = -6.84, p < .01$). Participants of all three workshops stated that the hands-on activities and interactions with museum artifacts and specimens were the most valuable components of the workshop. Many teachers indicated that they would be interested in attending more museum-associated workshops because "I have found them to be extremely helpful, informative, and interesting" (TT.WS16[1]), "There are always excellent museum staff associated with the workshops" (TT.WS2), and "[Museum name] offers quality workshops with a scientific/educational viewpoint" (TT.WS13).

In follow-up interviews and surveys, educators continued to identify elements of the museum-associated workshops that made them unique and especially significant experiences. As one teacher explained, "Hands-on opportunities [allowed us to] interact with behind-the-scenes museum specimens. . .and artifacts that you could touch and categorize" (SCS.FI4). Another teacher indicated that "the hands-on activities and discussion with other teachers" (SCS.FS7) were important elements that enhanced the professional development experience.

Models Compared: Museum-Based, Field and Museum-Based, and Field-Based Workshops

Mean ranks for each workshop demonstrated the overall highest ranking for Model B, the museum and field-based workshop ($M = 4.80, SD = .41$), the second highest ranking for Model C, the field-based workshop ($M = 4.50, SD = .52$), and the lowest ranking for Model A, the museum-based workshop ($M = 4.13$, $SD = .62$). A one-way ANOVA was conducted with the data to determine if there were statistically significant differences in how individuals ranked the museum-sponsored workshop. Significant differences were found between participants of Model B and Model A ($F = 7.78, p < .01$). Model B was one that combined elements of the other two, providing a mixture of museum-based activities and fieldwork and also garnished the highest ranking. This information indicates that field experiences within a professional development workshop are perceived as more valuable when combined with concrete classroom connections. Model A, the museum-based workshop, had no field time and the least amount of contact time with experts-scientists out of the three. It also received the lowest ranking.

Increased Understanding of Science Content and Scientific Processes

Teachers were asked to rank their perceived knowledge level of specific topics before and after participation in the workshop. Statistically significant gains in perceived content knowledge were found within each of the workshops and for all content-related survey questions (see Table 1). Model A had primary focus on

[1]All qualitative data was coded to identify the (a) type of workshop (Southern California = SC), Tiniest Teachers = TT, or Ecology and Paleontology = EP), (b) type of data (workshop survey = WS, follow-up survey = FS, or follow-up interview = FI, teacher interview 2 years later = TY), and (c) teacher identification number.

Table 1
Gains in Science Content Knowledge (Self-Report)

		Preworkshop		Postworkshop			
	N	Mean	*SD*	Mean	*SD*	*t*	*p*
Model A: Museum-based							
Formation and general history of tar pits	16	2.00	.894	4.00	.516	−3.54	<.01
How animals became trapped and preserved in the pits	16	2.44	.964	4.06	.574	4.78	<.01
Lifeways of the Chumash Native Americans	16	2.60	1.454	4.07	.799	4.36	<.01
Impact of the automobile on southern California culture	15	2.53	.990	3.93	.594	4.37	<.01
Model B: Museum and field-based							
General arthropod information	20	2.20	.894	4.00	.649	11.57	<.01
Model C: Field-based							
Concepts in desert ecology	18	2.89	1.323	4.17	.618	4.42	<.01

content and classroom activities, less emphasis on process, and less contact time with a museum scientist than in the case of Model B and Model C. For each content area presented in each workshop model, a survey question probed participant knowledge gain. For Model A, this meant that there were more survey questions related to content knowledge than for the other two models.

In addition to imparting content knowledge to participants, Models B and C also focused on science processes, primarily through interaction with practicing scientists, first-hand field experience, and interaction with authentic specimens. Survey results indicated that participants felt that they had acquired a greater understanding of the scientific process, specifically field-research methods (see Table 2). One participant reported the importance of gaining knowledge through

Table 2
Gains in Science Process Knowledge (Self-Report)

		Preworkshop		Postworkshop			
	N	Mean	*SD*	Mean	*SD*	*t*	*p*
Museum and field-based							
Field research techniques used to study arthropods	18	1.83	.924	4.17	.707	11.78	<.01
Field-based							
Paleontology field methods such as locating and collecting fossils	18	2.17	1.383	4.11	.90	7.10	<.01

Table 3
Options Listed on Each Model's Survey of Most Helpful Workshop Elements

Model B: Museum and field-based	Model C: Field-based
Classroom activities	Classroom activities
Informational handouts	Informational handouts
Learning research methods	Learning research methods
Field guide to take home	Salary point credit
Spending time in the field	Spending time with a paleontologist
Spending time with an entomologist (scientist)	Spending time with an ornithologist
Interaction with live animals	Learning to link with national standards
Learning about the museum and what it offers	Learning about the museum and what it offers

authentic specimens and scientific field investigations "to really see what you're learning about" (TT.WS17).

Participants in Model B and Model C completed a survey question asking them to indicate workshop elements they found most helpful to them as an educator. The intent was to determine to what extent interacting with scientists was determined as helpful. The eight options for each survey are summarized in Table 3.

For Model B, the two top responses, with 12 votes each (each participant could select up to three elements), were "spending time with an entomologist" and "classroom activities," indicating the importance placed on the opportunity to interact with museum scientists and, equally, the classroom activity portion. Comments also supported this finding: "I really enjoyed [name of entomologist] — it's nice to have access to an 'expert"' (TT.WS6) and "The combination of scientific information, hands-on activities, and take-home materials is very helpful" (TT.WS12). For Model C, the two top responses, with 13 votes each, were "spending time with a paleontologist" and "spending time with an ornithologist," indicating the importance placed on the opportunity to interact with museum scientists. Comments also supported this finding: "Having the experts right there for questions and answers was so helpful" (EP.WS14) and "seeing paleontologists getting excited and sharing knowledge" (EP.WS11).

One participant of workshop Model C, the field-based approach, clearly explained how ornithologist-led investigations in conjunction with authentic research tools were helpful in building the participant's knowledge base: "I am severely lacking in bird knowledge. The spotting scopes and telescopes were great!" (EP.WS7). Another teacher commented, "Nothing can replace field experience" (EP.WS18).

Enhanced Science Instruction (Content, Pedagogy, and Curriculum Knowledge)

All three models had an emphasis on classroom instruction, though Model A had the greatest emphasis on this transfer, followed by Model B, which gave equal

Table 4
Self-Report of Knowledge Gains Related to Classroom Activity Ideas

		Preworkshop		Postworkshop			
	n	Mean	*SD*	Mean	*SD*	*t*	*p*
Museum-based workshop							
Classroom activities for teaching about ice-age animals and tar pits	16	1.93	1.280	3.80	.862	5.33	<.01
Classroom activities for teaching about the Chumash	16	2.44	1.504	3.94	.854	4.56	<.01
Classroom activities for teaching about this impact (of the automobile on southern California culture)	16	2.00	.730	3.75	.775	6.58	<.01
Creating and using discovery kits	16	2.69	1.138	3.75	.577	3.60	<.01
Using problem-based learning	16	3.00	.966	3.88	.619	3.22	<.01
Museum and field-based workshop							
Insect/Arthropod activities for the classroom	20	2.25	.91	4.30	.733	13.36	<.01
Field-based workshop							
Classroom activities for teaching about paleontology	18	2.11	1.367	3.67	.840	6.34	<.01
Classroom activities for teaching about desert ecology	18	2.39	1.290	3.78	.808	5.40	<.01

emphasis to content and process and pedagogy. Model C discussed classroom applications, but not as often as the other two models. In spite of these differences, participants in all three courses indicated that after participation they had a stronger understanding of effective science instruction techniques related to the content of each workshop (see Table 4).

One Model C participant expressed experience with fieldwork and scientific processes really connected to classroom science teaching, making "the whole picture clarified" and, specifically, "ways to explain scientific info more clearly" (EP.WS17). Another stated that the workshop assisted in "personal growth to feel more comfortable teaching the subject matter" (EP.WS7). Model B participants, who received the combination of museum and field-based experiences, reported that they were more clear on how to make the connection from field to classroom, noting that the workshop information would be beneficial when working with students. Teachers reported that the workshop would help them "identify insects" (TT.WS7), expand on "field techniques. . .really geared toward educators" (TT.WS11), and "set up an insect zoo in class so all of the information shared will be helpful" (TT.WS3).

Increased Awareness of Museum Resources Due to Museum-Associated Workshops

One goal of all three workshops was to increase participant awareness of the resources offered by the museum to support their classroom instruction. Examples include free curriculum guides, free admission for educators, and a loan service enabling teachers to borrow artifacts and specimens for 2 weeks' use in their classroom.

The survey used for Model A, the museum-based workshop, specifically asked if participants were more aware of museum resources after participation in the workshop. Participants indicated through self-report that participation in the workshop had led to an increased knowledge of available resources (see Table 5).

When asked to indicate which elements from workshops Model B and Model C were the most helpful to their teaching, participants had the option of choosing "learning about museum resources" (see Table 3). However, only a few participants from Model C selected this element ($n = 3$), and only one participant selected this element from Model B. In addition, participants did not mention the idea of museum resources in any of the open-ended responses or comment requests.

At the time of this study, there was no central system to formally track follow-up visitation. However, there were informal indicators that some teachers had become more aware of what the museum had to offer. One participant was seen visiting the museum the following week to check out class materials. A few other teachers enrolled in additional museum courses and teacher events. Teachers seeking salary point credit through their school district were required to complete an instructional unit on the workshop's subject matter. In each workshop's culminating assignment, nearly all featured the use of museum resources, such as exhibit tours, loan-service items, and Web-site resources in the unit.

Table 5
Self-Report of Knowledge Gains Related to Classroom Activity Ideas

		Preworkshop		Postworkshop			
	n	Mean	*SD*	Mean	*SD*	*t*	*p*
Museum resources available to teachers	16	2.56	1.094	4.06	.772	4.39	<.01

Postworkshop Follow-Up

Four- to Six-Month Follow-Up

The first follow-up contact with participants took place 4–6 months after the workshops. Teachers who were interviewed ($n = 12$) or returned completed surveys ($n = 16$) reported that they were applying content and instructional strategies gained from the workshop to their science lessons. In addition, they reported that they changed their science instruction in some way as a result of their participation in the workshop. One teacher said, "Now I focus on what is more relevant to the kids with hands-on activities. Before this workshop, I used a lot of worksheets" (EP.FI5). Another teacher said, "My science lessons consist of more active inquiry and investigation" (EP.FS4). One teacher explained that "Background knowledge is very valuable for a teacher to be able to understand the whole picture" (EP.FS2). Patterns across interviews and follow-up surveys included ways that teachers would change their classroom teaching: (a) experiences in the field helped teachers implement similar field activities in their classroom and (b) hands-on components motivated teachers to include more realia while teaching science. One teacher noted, "I enjoyed [the workshop]. Field-based experiences helped me get out and do it. In order to do these types of activities with kids, teachers need to do it" (TT.FI2).

Two-Year Follow-Up

The follow-up questionnaire again reiterated feelings and opinions shared in the postworkshop questionnaires and interviews. One questionnaire asked participants to rank on a 7-point Likert-type scale (1 = *much less helpful* and 7 = *much more helpful*) "How would you compare the workshop you attended at the museum with most other (nonmuseum) workshops you have attended?" Respondents ($n = 17$) indicated that they still found the museum workshop had been more helpful than other workshops they attended ($M = 5.65$, $SD = 1.17$). They reported referring to activities from the workshop approximately every 2 months, as well as information from the workshops slightly more often. In addition (as indicated on a 5-point Likert-type scale, with 1 = *completely false* and 5 = *completely true*), participants indicated that "because of participation in the museum workshop" they were:

1. better able to explain the process of science to students ($M = 4.24$, $SD = .56$)
2. more likely to conduct science activities with their students ($M = 4.47$, $SD = .51$)
3. better able to explain the work of scientists ($M = 4.24$, $SD = .66$)
4. more likely to conduct object-based activities with students ($M = 4.47$, $SD = .51$)
5. overall more comfortable teaching science ($M = 4.59$, $SD = .51$).

Such comments as "the homework assignment was helpful in understanding the process of making a unit to teach" (EP.TY7) and "first hand-experience that I can share with my students" (EP.TY10) are examples of responses obtained from questionnaires. One teacher added "the only one I had attended like it" (EP.TY9), reinforcing the novel experiences that informal learning institutions can provide.

Using the final follow-up questionnaire, comparisons were again made between workshops. Interestingly, the return rates were not constant for all three workshops, with the museum and field (Model B) and field-only (Model C) workshops having a higher return rate (in relation to attendance numbers) than the museum-based workshop (Model A). Museum-based workshop participants returned only two questionnaires, so these were disregarded for this comparison. Given prior information that the museum-based workshop had not been perceived as being as helpful to participants, there is question as to whether low return rates were in any way related to this. Specifically, those educators who did not have positive feelings may not have taken the time to complete the follow-up survey.

Regarding Model B and Model C, there were no statistical differences in educator responses to the questions summarized above, with one exception: Though both ranked highly, Model B participants provided a statistically higher ranking ($M = 6.00$) than did Model C participants ($M = 5.00$, $F = 4.951$, $p < .05$). No other statistically significant differences in rankings were observed. In summary, the impact of the workshops on participants was strong enough that a good number of participants were still referring to information and activities at least 2 years later.

Limitations

Although the three models shared many features, disparate elements, such as venue and schedule, made comparisons across cases difficult. However, this limitation is mediated when the study is looked at as an exploration into several viable models of inservice, rather than with a goal to conclusively identifying one as more effective over the other. A second limitation is that this study relies on participants' self-report of gains in content knowledge and pedagogical knowledge as the primary indicator of outcome. An attempt was made to collect more objective data on content gains with the field-based workshop through the administration of a content test at the end of the course. However, despite requests that they complete the test on their own, participants treated the measure as a group activity, thus leaving the results nebulous at best. One could counter this concern, however, that, with a goal to increase educators' comfort and confidence with science content and science instruction, a self-report measure is perhaps the most appropriate measure as it connects directly to self-efficacy and confidence.

Conclusion and Discussion

Directly after participation, educators had positive feelings about their experiences, offering such comments as "I will always talk about this trip — forever. It was a high point, and my kids will love hearing and learning about all aspects of it!" (EP.WS9). "These are very valuable workshops in order to have personal growth and to feel confident in teaching the subject material" (EP.WS7). Follow-up 2 years later confirmed that educators retained their positive feelings about the workshops and that they continued to infuse elements from them into their classroom curriculum.

Cumulatively, teachers reported that they (a) increased their understanding of science content related to the content of the workshop, (b) valued working with scientists in field settings or in a museum with various collections, and (c) valued workshops conducted within informal environments when explicit links to science instruction were addressed. Teachers who participated in either of the workshops that included fieldwork, Models B and C, reported specific elements from the workshops that helped them understand the process of science and scientific fieldwork.

The three workshops investigated during this study followed different formats, though all three were considered to be positive experiences by the participants and enhancements of classroom science instruction and professional knowledge. The teachers indicated that they especially enjoyed working with the scientists, museum educators, museum specimens, exhibits, and interdisciplinary content. Specifically, participants in the combination course that included the museum and a scientific field site ranked it statistically higher than those in the other two courses.

Although this study is small in scope and investigates three workshops at one facility, we feel it provides important guidance to those who educate our preservice and inservice teachers, both in traditional and informal settings. Teachers in this study reported that time at the museum, connections to the science instruction, and scientific fieldwork proved the most valuable for professional development. These results support Neathery's (1998) findings that informal science settings offer an array of resources usually unavailable in schools. Museums help teachers develop knowledge about available on-site or on-loan community resources. Field experiences provide opportunities for teachers to participate in authentic scientific investigations (i.e., experiences based in actual ongoing scientific study) that can be translated into field investigations near their school site. These types of programs empower teachers to make better decisions about science instruction by increasing their understanding of community resources available, science content, scientific processes, and pedagogical models. We hope that after completing such workshops, teachers may feel more confident communicating with museum scientists and educators, coordinate museum content with their district science standards, engage in science field methods with their students, and model instructional strategies that encourage students to inquire about scientific phenomena. However, there is still a need for more concrete data to support these goals as observable outcomes.

Although many informal science institutions offer some type of professional development for teachers, the results of such programs have not been widely disseminated. This study adds to the professional development literature in science education because it highlights the value of integrating museum resources and field investigations with science classroom practices. Huinker (1996) noted that urban teachers of science often face additional challenges in providing a quality science program to students, specifically limited professional development opportunities in science, as well as a weaker background and knowledge base in the sciences than in other curricular areas. Often located in the heart of these urban environments, informal sites, such as museums, can certainly address and assist with both of these barriers our urban educators face. As scientists are asked to take an active role in the education of science teachers (National Research Council, 1996b), science educators must seek additional information about the role of scientists and how their involvement enhances science teacher development over time. These results provide preliminary information about teacher learning and development within informal contexts. More investigations are required to determine how these contexts can provide greater science enhancement and ongoing professional development for teachers.

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