University K–12 Science Outreach Programs: How Can We Reach a Broad Audience?

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Scientists conducting kindergarten through twelfth-grade (K–12) outreach often use an expert-driven innovation-adoption model for the dissemination of ideas, similar to the model used in agricultural extension programs. However, social-learning approaches that emphasize the ongoing professional development of educators and the importance of learning from peers may be more appropriate for K–12 classrooms and nonformal educational settings. Building on the innovation-adoption and social-learning literature, I propose a model for K–12 program dissemination. How well a program reaches its dissemination goals depends on the interaction of educators and their context with factors related to program designers and their context, to dissemination strategy, and to the innovation being disseminated. Dissemination goals include the number of educators who either adopt a standard curriculum or adapt program principles and resources to meet their needs, and how well the educators' programs reflect the designers' educational philosophy. The proposed model can be used to inform program design and educational research.

Keywords: K–12 education, university outreach, innovation adoption, social learning, program dissemination

Although universities and government agencies expend significant resources developing innovative curricula for kindergarten through twelfth-grade (K–12) audiences, many of the new materials are never widely used by teachers or educators working in out-of-school (nonformal) settings (Louis and Jones 2001, Owens 2001). For example, of the 20,000 teachers trained since the inception of the GLOBE (Global Learning and Observations to Benefit the Environment) multiagency program, only about 1000 report data for any protocol in any given year (Penuel et al. 2004). In the Cornell In-Touch Science program, just over 40 percent of the educators who attended workshops followed up with educational activities for youth (Spencer at al. 2002), and in the Garden Mosaics program, 42 percent of the workshop participants who responded to a survey had implemented at least one aspect of the program (Thompson 2003).

Furthermore, teachers who implement new curricula often do so in ways that are not consistent with the original program's philosophy or principles (Cohen and Ball 1999, Spencer et al. 2002, Barab and Luehmann 2003, Squire et al. 2003). For example, although authentic inquiry is an underlying principle of many contemporary curricula, teachers may find student inquiry in conflict with their ongoing teaching practices. When teachers adapt inquiry-based or otherwise innovative curricula to make them more consistent with familiar teaching methods, the resulting activities may lose their focus on inquiry or their other novel qualities (Hutchinson and Huberman 1993, Louis and Jones 2001, Owens 2001). In short, "while university-based researchers can develop successful and innovative 'boutique' projects that may impact a handful of highly motivated teachers with whom we work directly, these innovations do not usually result in the large-scale dissemination and long-term sustainability necessary for truly bringing about educational change" (Barab and Luehmann 2003, p. 464).

Thus, a key issue facing faculty and others developing inquiry-based and innovative curricula is how to facilitate the widespread use of the materials in a way that is consistent with the program philosophy or principles, a process referred to here as *dissemination.* In this article, I present a preliminary model for the dissemination of K–12 curricula (figure 1), using examples from several K–12 outreach programs (box 1) and drawing heavily from innovation-adoption and social-learning theory (table 1). I hope that such a model will generate discussion and hypotheses for further testing, thus encouraging scientists to take a more critical, research-based perspective in their outreach efforts.

Innovation-adoption versus social-learning theory

For over 40 years, Everett Rogers's comprehensive reviews of how innovations diffuse from developers to users have framed how many university faculty conduct outreach (Rogers 2003).

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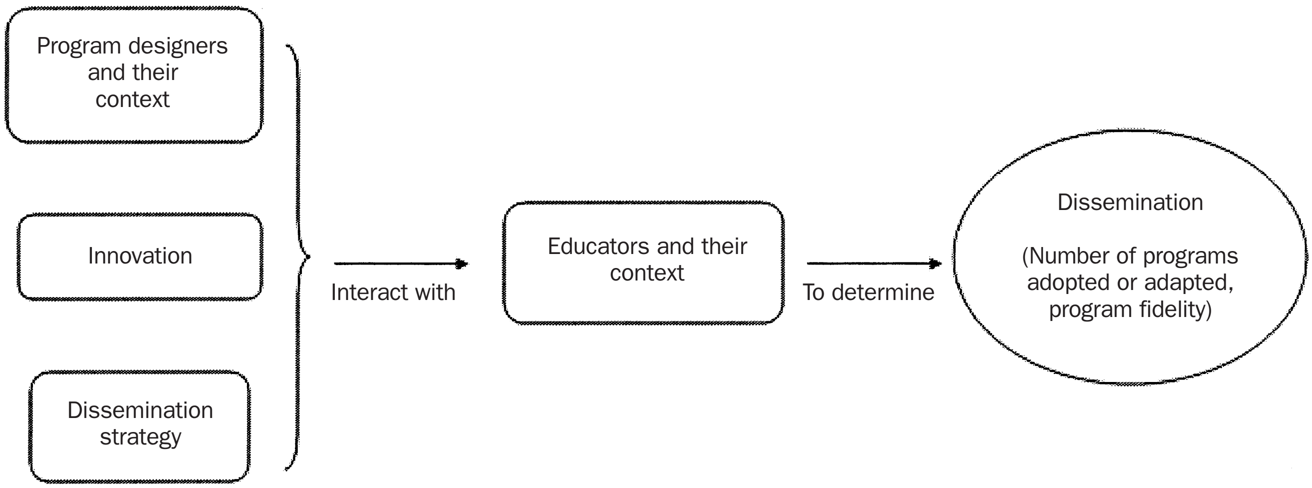

Figure 1. Factors affecting the dissemination of K–12 science outreach programs. Program designers can vary factors over which they have control, including their own commitment and skills, the nature of the innovation, and the dissemination strategy; designers need to consider how these factors interact with educators and their context. Program designers also decide whether they are most interested in educators adopting the program as is or adapting it to fit local needs, and how to incorporate strategies that promote program fidelity. Educational researchers can use the model to design manipulative experiments examining the effect of factors that they can control (e.g., dissemination strategy) and factors that have natural variation (e.g., educators and their context, organizational context of program designers) on the numbers and fidelity of programs implemented.

According to the innovation-adoption model, which has been variously referred to as "expert-driven," "top-down," or "research-to-practice," university experts create technologies, or *innovations,* which are then adopted by willing users. Rogers's work draws heavily from Cooperative Extension, in which state (land-grant) university faculty and county agents work together to disseminate the results of university research in agriculture, nutrition, and other disciplines. (Although the Cooperative Extension System also includes the US Department of Agriculture, in this paper I focus largely on the university–county partnership.)

A number of of education scholars have suggested that a system developed for reaching farmers in the early to mid-20th century does not meet the complex needs of the contemporary sustainable-agriculture movement. These individuals have proposed social-learning strategies, which emphasize participatory, bottom-up, problem-solving approaches to the creation and sharing of knowledge (Leeuwis and Pyburn 2002). Similarly, education scholars have proposed a variety of social-learning approaches for work with K–12 audiences, including communities of practice, communities of purpose, design experiments, teacher networks, and learning communities (Loucks-Horsley et al. 1998, Lieberman 2000, Barab et al. 2002, Barab and Luehmann 2003, Schlager and Fusco 2004).

Programs using a social-learning approach incorporate opportunities for educators to create their own meanings or practices by reflecting on what they are learning, by relating new ideas to existing knowledge, and by interacting socially, and thus are consistent with constructivist theories of learning (Hutchinson and Huberman 1993, NCDDR 1996). Teachers engaged in such constructivist learning are active problem solvers rather than passive recipients of knowledge from "training experts"; they modify the innovation to suit their needs, and share ideas with the program developers. Through their active involvement in creating and modifying the innovation, they feel a greater sense of propriety over the new practice, and therefore will be more likely to implement it (Hutchinson and Huberman 1993, Barab and Luehmann 2003). Thus, "the process of dissemination is not simply 'rubber-stamping' the same program into multiple contexts; rather, the process of large-scale adoption involves additional, individual teacher-directed design, fitting, and adaptation for local circumstances" (Barab and Luehmann 2003, p. 454). Furthermore, the reflection that occurs when individuals with different knowledge and backgrounds engage in discussions of how to address common concerns may be crucial to the dissemination of educational programs (Louis and Jones 2001). In short, whereas the goal of an innovation-adoption approach is replicating a particular practice, the focus of a social-learning approach is on teachers or other practitioners adapting innovations to their particular setting through ongoing professional development.

Toward a model for dissemination of K–12 outreach programs

By examining factors that both the innovation-adoption approach and the social-learning approach suggest affect the success of dissemination, we can gain useful insights for designing programs and can develop a model that can be tested by further research. In the proposed model, factors related to program designers and their context, to the innovation itself, and to dissemination strategy all interact with the educators and their context to determine how well the program reaches its dissemination goals. Dissemination goals include the number of educators who either adopt a standard curriculum or adapt program principles and resources to meet their needs (programs may fall on a continuum between these two extremes), and how well the educators' programs reflect the designers' educational philosophy (figure 1, table 1).

Educators and their context. Factors affecting dissemination that relate to educators and their context are listed in box 2. Rogers (2003) places a great deal of emphasis on the characteristics of individuals that promote their willingness to adopt new practices. He describes "innovators" and "early adopters" as those with higher levels of education and socioeconomic status relative to "late adopters" and "laggards." While this work has been criticized for its assumption that the adopters were somehow better than the nonadopters (Stephenson 2003), it is still useful to consider factors related to training and other characteristics of teachers and other audiences. For example, a challenge for many K–12 outreach programs is how to prepare teachers to guide students in research and other forms of inquiry, when many teachers have limited backgrounds in science (Songer et al. 2003).

The organizational and professional context in which teachers work also influences the spread of innovations. Unfortunately, schools often do not provide the incentives, resources, and opportunities for teachers to share practices that would create a fertile environment for curriculum innovations to grow and spread (Palincsar et al. 1998, Barab et al. 2001). Teacher professional organizations may provide networking and support for K–12 dissemination efforts, but only a subset of the more active teachers participate.

The political context of educators also can be important. Whereas Cooperative Extension was developed to give in-

Box 1. K–12 outreach programs mentioned in this article.

Citizen Science (*www.birds.cornell.edu/LabPrograms/CitSci/index.html*), Cornell Laboratory of Ornithology: Promotes scientific inquiry through children's natural fascination with birds while contributing to bird study and conservation.

Explorations from an Aerial Perspective (*http://iris.css.cornell.edu/rip/eap/eap.htm*), Cornell University Institute for Resource Information Systems: Enables K–12 educators to incorporate aerial photographs and maps into investigations of local environments and land use history.

Garden Mosaics (*www.gardenmosaics.org*), Cornell University Department of Natural Resources: Connects youth and elders to investigate the mosaic of plants, people, and cultures in gardens.

GLOBE (Global Learning and Observations to Benefit the Environment) Program (*www.globe.gov*), National Aeronautics and Space Administration, National Science Foundation, and US State Department: Improves students' understanding of science by involving them in performing real science, including taking measurements, analyzing data, and participating in research in collaboration with scientists.

Inquiry Learning Forum (*http://ilf.crlt.indiana.edu*), University of Indiana: Seeks to improve student learning by supporting teachers in better understanding inquiry-based teaching and learning.

In-Touch Science (*www.intouch.cornell.edu*), Cornell University Department of Textiles and Apparel: Helps children in grades 3 through 5 link the science they study to the science they experience in their lives.

Tapped In (*http://ti2.sri.com/tappedin/*), SRI International: Enables program designers to provide cost-effective online professional development experiences and support to teachers.

Wonderwise Women in Science (*http://wonderwise.unl.edu*), University of Nebraska State Museum: Introduces youth to women who have made science their career.

Box 2. Factors affecting the dissemination of educational innovations: Educators and their context.

Educators

Background: Do the individuals implementing the program have background in science content, inquiry, and research?

Commitment: Are educators committed to the program principles? Have they made the decision to implement the program themselves, or do they feel pressured to implement it?

Organizational context

Resources: Are supplies, computers, transportation, and adequate funding available within the organization?

Organizational mission and norms: Does the organizational culture support innovation and collaboration? Is science education central to the organization's mission?

Administrative leadership: Does the organizational leadership promote innovation and collaboration?

Professional context

Professional development and networking: Do the educators have ongoing opportunities for professional development and networking?

Political context

Consensus: Is there consensus at the policy level that favors the innovation?

Funding climate: Do government policies provide a favorable funding climate for the innovation?

Table 1. Overview of innovation-adoption (Rogers 2003) and social-learning approaches to the dissemination of innovations.

Factors affecting dissemination	Innovation-adoption approach	Social-learning approach
Goal	Adoption of new practices	Professional development and ongoing learning, leading to adaptation of new practices to meet needs of individual settings
Educators and their context	Educators and other audiences categorized as innovators, early or late adopters, or laggards	Greater attention paid to educator context, including resources, support of administration and peers, and ongoing networks that provide opportunities for learning from peers
Designers and their context	Concern about heterophily (differences in education, speech, etc.) between designers and implementers	Long-term commitment to supporting the professional development of educators
Innovation (curriculum, practice, or program) being introduced	Emphasis on relative advantage, compatibility, complexity, "triability" (ability to try out the program), and observability	Emphasis on incorporating opportunities for adaptation into curriculum or other innovation; need to define core principles in order to promote implementation fidelity
Dissemination strategy	Innovations spread through "change agents" (e.g., county extension agents), opinion leaders, and peer networks	Innovations spread through learning from peers in communities of practice and other educator networks

Source: Loucks-Horsley et al. 1998, Lieberman 2000, Barab et al. 2002, Leeuwis and Pyburn 2002, Barab and Luehmann 2003, Schlager and Fusco 2004.

formation to individuals operating in a relatively neutral environment (the goals of agriculture, i.e., increasing production, were widely agreed upon), schools operate in a highly politicized context (Louis and Jones 2001). Education researchers, policymakers, and practitioners have failed to come to a consensus on overall goals, creating a barrier to expert-driven models of dissemination (Palincsar et al. 1998). For example, agencies such as the National Science Foundation (NSF) promote inquiry-based learning, whereas the "No Child Left Behind" Act of 2001 attempts to impose standardized testing that may not promote inquiry. Thus, in contrast to farmers, who may go out of business if they cannot keep up with new technologies, teachers may be penalized if they adopt innovations that do not lead to increased test scores for their students.

Box 3. Factors affecting the dissemination of educational innovations: Program designers and their context.

Program designers

Heterophily/previous history with audience: Do the program designers share a common "language" with the educators? Do they have a trusting relationship with the educators, built through previous collaboration? Do they understand the cultural norms in the classrooms or nonformal science education settings where they are working?

Commitment: Are program designers committed to the project for the long term (through the dissemination stage)? Have they made the decision to become involved themselves, or do they feel pressured by funding agencies or administration?

Planning and experience: Have program designers given serious thought to the dissemination plan? Are program designers familiar with the dissemination literature, or do they have experience in dissemination?

Institutional context

Support: Does the program designers' administration reward and otherwise support outreach? Is there a center or individual that provides campus-wide leadership for K–12 outreach? Does the program designers' institution have ongoing resources to support outreach?

Program designers and their context. Factors affecting dissemination that relate to program designers and their context are listed in box 3. Rogers (2003) uses the term *heterophily* to refer to differences in education, speech, and related characteristics between the university faculty who develop innovations and the farmers who use them. Such differences may hamper communications and thus limit dissemination (Rogers 2003). To bridge this gap, Cooperative Extension has long employed "county extension agents," who often have farming backgrounds, and who serve as intermediaries between university scientists and farmers as well as help facilitate farmer networks that aid in spread of new practices. The Pilot State Dissemination Project during the 1970s used a similar system of local "dissemination agents" acting as intermediaries between researchers and school districts, but the project was never expanded nationwide because of concerns about costs (Hutchinson and Huberman 1993).

Because Cooperative Extension programming has been viewed as a core function of land-grant universities since the early 1900s, and until recently has had relatively stable funding, it has been able to attract faculty who have a long-term commitment to outreach and who thus provide ongoing support for farmers through workshops, publications, and being available to answer questions. Furthermore, universities have statewide Cooperative Extension offices, which coordinate extension activities on campus and facilitate communication between faculty and county agents. In contrast, engagement of science faculty in K–12 outreach has expanded rapidly over the last decade, largely in response to pressures from the NSF and other funding agencies (e.g., merit review criterion 2 for NSF proposals, which focuses on broader impacts of science research). Developers of NSF-funded K–12 educational programs may have little background in educational outreach and may be uncertain of their long-term commitment. In addition, universities may not have administrative and leadership structures in place to support the growing number of K–12 outreach efforts; thus, communication among the faculty conducting programs, and among universities and schools, is often limited.

Innovation: Curriculum, practice, or program. Factors affecting dissemination that relate to the innovation (curriculum, practice, or program) being disseminated are listed in box 4. Much of Rogers's (2003) writing focuses on defining the characteristics of innovations that promote their adoption, including potential users' perception of their *relative advantage* compared to current practice (e.g., economic, social prestige, convenience); their *compatibility* with existing values, experiences, and needs of potential adopters; the ability of potential users to *try out* or *observe* the results of the new practice; and the *ease* with which potential users can understand and use the innovation. Several NSF-funded K–12 outreach programs, including the Wonderwise program from the University of Nebraska and the In-Touch Science, Garden Mosaics, and Laboratory of Ornithology Citizen Science programs from Cornell University, illustrate some of these principles. For example, NSF and university backing is likely to provide legitimacy or prestige for these programs in the eyes of the implementers. Because of the current concern about inclusion of females and minorities in science, the Wonderwise program's focus on scientists who are women of color, and the incorporation of local knowledge of minorities and immigrants in the Garden Mosaics program, are examples of compatibility with the values, experiences, and needs of potential adopters, which has also been referred to as taking advantage of "idea cycles" (William Penuel, SRI International, Menlo Park, CA, personal communication, 12 March 2004). Another factor is a program's "charisma." For example, students and educators may find birds charismatic subjects of study, which may partly explain the success of the Cornell Laboratory of Ornithology's Citizen Science programs. To make the programs easy to implement and the activities observable, the Wonderwise and In-Touch Science programs use kits that include all necessary supplies and are presented to educators at workshops (Hutchinson and Huberman 1993, Rogers 2003). Despite the kit format, which often characterizes more "canned" programs, Wonderwise and In-Touch Science are adaptable to many different settings, including 4-H clubs, camps, and after-school programs, and to programs of varying length (Charlotte Coffman, Cornell University, Ithaca, NY, personal communication, 29 March 2004). Social-learning theory would suggest that strategies to help educators to adapt curricula should be incorporated into the program design (Barab and Luehmann 2003, Squire et al. 2003). In such flexible programs, faculty introduce educators to research-based tools and ideas, which the educators then use to design and pilot individual programs that meet local needs (Mordock and Krasny 2001, Krasny and Doyle 2002). The educators may then share the results of their local teaching experiments, thus furthering understanding of educational practices. For example, through the Explorations from an Aerial Perspective program, Cornell faculty trained 4-H and other educators in aerial photography and topographic map interpretation, and each educator then designed a local project in which youth conducted a land-use investigation using aerial photographs and maps (Mordock and Krasny 2001). In one such project, youth in an after-school club used aerial photographs to trace changes in land use in their New York City neighborhood from beach cabanas to vacant lots, incorporated what they learned from the photographs and from subsequent interviews of "old timers" into a film, and helped lead their community in planning for future use of the

Box 4. Factors affecting the dissemination of educational innovations: Innovation (curriculum, practice, or program).

Ease of use/observability/triability: Is the new program simple to use? Does it involve relatively small changes in current practices? Can a prospective educator readily observe the program being implemented or try it out? Are the principles and activities clearly presented, and is the language appropriate for the audience?

Relative advantage: Does the program offer an advantage over current practice?

Comprehensive: Does the program meet multiple needs of prospective educators (e.g., multiple subject areas or grades)?

Prestige: Does the program have backing by a prestigious institution (e.g., a university) or government agency (e.g., the National Science Foundation)? Does someone famous or well respected within the community of potential implementers back the program?

Idea cycle/charisma: Does the program fit with ideas that currently are popular (e.g., multiculturalism)? Does the program focus on charismatic subjects?

Adaptability: Can the program be readily adapted to different settings?

Length of funding: Does the program have funding for a sufficiently long period for dissemination to take place?

Table 2. Implementation of activities from the Garden Mosaics program by educators participating on the Garden Mosaics Leadership Team, educators attending one- to two-day local workshops, and educators attending short workshops or presentations at conferences.

	Educator participation (percentage)		
Activities implemented	Leadership Team (*N* = 15)	Local workshops (*N* = 8)	Conference presentations (*N* = 7)
Garden Hike	92	62	14
Gardener Story	46	50	29
Neighborhood Exploration	58	38	0
All three investigations	47	38	0
Action Project	30	50	57
Science Pages	54	25	43

Note: Numbers for local workshops and conference presentations are for those who responded to survey; see table 3 for response rates. All Leadership Team members responded to the survey.

vacant lots. Descriptions of this and other local projects were included in the program manual and thus were shared with other educators (Barnaba et al. 2000).

A problem with flexible programs is that educators may adapt them in ways that are not faithful to the original principles (Cohen and Ball 1999, Squire et al. 2003). Sometimes program directors sacrifice fidelity to their educational philosophy in order to empower participants and increase implementation. An example comes from the Cornell In-Touch Science program, a fundamental principle of which was "paired activities" designed to integrate a basic and an applied science (e.g., chemistry and environmental science). According to the In-Touch Science director,

> In workshops and pilot studies, participants learned and embraced this philosophy, but in practice they did not feel that linking the paired activities was sufficiently important to take the time to do this somewhat difficult task. Most users were integrating ITS [In-Touch Science] into their own larger programs (4-H, Girls Inc., YMCA, etc.). Thus, if they were doing nutrition education, they felt justified to focus on the foods activities. If they liked Activity A but disliked gathering the supplies for Activity B, they simply didn't do Activity B. To some extent, we trainers gave tacit permission. Although we stressed the importance of doing the paired activities together and that this was a unique aspect of In-Touch Science, we also promoted the program as being adaptable and acknowledged that the leaders knew their students better than we so they should decide what to teach. (Charlotte Coffman, Cornell University, Ithaca, NY, e-mail communication, 29 March 2004).

Similarly, in Cornell's Garden Mosaics program, even the educators from the "Leadership Team," who played a major role in creating the program, picked and chose activities and adapted them to fit their needs (table 2). Eventually, because the program was being implemented in so many different ways, questions were raised about what actually defined a Garden Mosaics program. In response to this concern, the program designers identified four fundamental principles (science learning, intergenerational mentoring, cultural understanding, and community action) and thus tried to define the limits of acceptable adaptations (Loucks-Horsley et al. 1998).

Some programs begin with a social-learning approach but eventually become institutionalized, leaving limited opportunity for discussion and reinvention, a phenomenon referred to as "reification" (Barab et al. 2004). At this point, unless educators are committed to continuing to learn and improve their practices, an innovation-adoption model of dissemination may be more appropriate than social-learning approaches.

Dissemination strategy. Factors that relate to dissemination strategy are listed in box 5. Whereas the innovation-adoption approach focuses more on short-term workshops and demonstrations designed to promote adoption of new practices, the social-learning literature emphasizes sustained interactions and ongoing learning (Louis and Jones 2001, Barab et al. 2002). In this respect, social learning echoes the recent literature on teacher professional development, which suggests that one-time workshops are unlikely to result in significant, long-term change in teacher practices, because teachers need opportunities to discuss such things as student misconceptions and pedagogical strategies, to translate their learning into practice, and to reflect on their practice (Loucks-Horsley et al. 1998, Garet et al. 1999). However, social-learning proponents recognize that such long-term approaches may not meet teachers' immediate need for a lesson that they can implement "tomorrow" (Barab et al. 2004). Professional development that meets teachers' needs for something immediate tends to be one-size-fits-all, imposed rather than owned, and without intellectual coherence (Barab et al. 2001); in other words, it is similar to the expert-driven models that social-learning advocates have criticized.

Communities of practice represent one social-learning framework for facilitating ongoing learning, developing new practices, and providing ongoing support and networking for

Box 5. Factors affecting the dissemination of educational innovations: Dissemination strategy.

Adoption versus adaptation: Does the program use an expert-driven or a social-learning approach?

Community of practice: Does dissemination occur through existing networks or communities, or does the program create its own network? Does the program target individual sites (e.g., urban community centers) or sites that are part of a network (e.g., 4-H clubs)?

Internet: Does the program use the Internet to create a community? Does the program use the Internet to post information and resources?

Relationships with organizations: Have the designers garnered support for implementation at appropriate levels within the organization (e.g., administrator, educator)?

educators (Palincsar et al. 1998, Barab et al. 2001, 2002, Wenger et al. 2002, Schlager and Fusco 2004). According to Wenger and colleagues (2002), communities of practice are "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (p. 4). In the ideal community of practice, novices (e.g., preservice teachers) learn through apprenticeships or through mentoring from more experienced practitioners (e.g., seasoned teachers), who themselves are interacting with and learning from peers on an ongoing basis (Barab et al. 2002). Individuals initially participate peripherally by observing the practices, and later become full members of communities of practice (Barab et al. 2004). Thus, communities of practice emphasize the learning that takes place in the context of the work environment, rather than that which occurs through outside training (Schlager and Fusco 2004).

Many university outreach programs take teachers out of their ongoing school or community of practice (e.g., other teachers within their school) and bring them onto campus to learn a new skill or curriculum. Teachers then try to implement their new skills in a school environment and network of peers that may not support the innovation. Without the support of their local, ongoing community of practice within the school, the teachers may not be able to sustain the innovation (Loucks-Horsley et al. 1998, Schlager and Fusco 2004). To provide ongoing support to the teachers who implement the programs, some projects have attempted to create their own communities of practice (Barab et al. 2004, Schlager and Fusco 2004). However, because a community of practice is by definition ongoing and has both novices and apprentices, it is nearly impossible to create a new such community to promote professional development and dissemination related to a single curriculum innovation. Instead, Barab and colleagues (2004) and Schlager and Fusco (2004) argue that we should refer to such narrower communities focused on a single project as bounded "communities of purpose" rather than communities of practice.

Furthermore, Schlager and colleagues (2002) suggest that rather than viewing a community of purpose as an outcome of an outreach program, program designers should embed their professional development and dissemination efforts within larger communities of practice in which these efforts can "take root, bloom, and propagate" (p. 17). However, this recommendation depends on the existence of ongoing communities of practice that provide the resources, incentives, and professional and social structures to sustain and expand innovations, and in which the members are enthusiastic about a particular curriculum innovation (Schlager et al. 2002, Schlager and Fusco 2004). Such communities are not always present in schools or nonformal education organizations.

Interestingly, the county Cooperative Extension agents working with 4-H programs have a network in which they share ideas and practices through regional, statewide, and national meetings as well as through ongoing phone and e-mail communications, and thus could be viewed as a community of practice. The NSF-funded Wonderwise and In-Touch Science programs provide examples of embedding new initiatives in this existing community of practice. The faculty developers were part of the 4-H system and thus were able to design curricula that complemented and improved existing 4-H programs rather than required educators to tackle something so radically different that it would have been difficult to implement (e.g., because of lack of resources or because of educators' inadequate science backgrounds; Louis and Jones 2001).

Findings from Cornell's Garden Mosaics program suggest that whereas a newly created community of purpose may play an important role in program development and provide professional development opportunities for its members, working with and sustaining such a community to effect widespread program dissemination is more challenging. The Garden Mosaics educator community, or "Leadership Team," consisted of 14 educators from nonprofit organizations, Cooperative Extension programs, and universities in 11 cities across the United States. Although initially the members of the Leadership Team were frustrated by not being given a more "canned," ready-to-implement curriculum, by the end of the second implementation season, they had played a major role in the development of a program that fit many of their needs (see *www.gardenmosaics.org*) and had achieved significant professional development goals as a result of their participation (box 6). Furthermore, over time, the Leadership Team members took the initiative to create new program activities, a process referred to as "co-evolutionary design" (Barab et al. 2004). However, Garden Mosaics is experiencing challenges in sustaining the Leadership Team over the long term, maintaining a focus on professional development, and providing ongoing support for educators as the number of participants grows. As a result, the program is building collaborations with national youth, gardening, and intergenerational organizations that already sustain ongoing educator networks; this

Box 6. Impact of Garden Mosaics program on Leadership Team members.

Responses of Garden Mosaics Leadership Team members to the open-ended question "What do you feel you have gained in terms of professional development and knowledge through your participation in Garden Mosaics this year?" are listed below. Numbers in parentheses were added if more than one educator gave a similar response.

Professional connections

Connections with Leadership Team members (4)

Connections with other professionals (2)

Closer relationships with gardeners

Experience in positive team building through effective communication

Awareness of national organizations

Awareness of existing garden education programs

Program and curriculum development

Ideas for program implementation (2)

Learning how to develop a national project

Understanding of place-based education, service learning

Experience with curriculum development

Value of multidisciplinary participation in program development

Understanding of science needs of schoolteachers and home-school groups

Teaching and communication skills

Teaching/training techniques and ideas (3)

Assessment techniques

Importance of modeling leadership characteristics expected from others

Content knowledge/new concepts and issues

Cultivation practices

Stronger appreciation for cultural and intergenerational inclusiveness

Urban horticulture

Knowledge of the growing significance of community gardens and food security

Issues affecting urban youth

Dissemination

Experience planning and conducting workshops

Working with local and regional partners to implement Garden Mosaics

strategy is consistent with the recommendations of Schlager and colleagues (2002) to embed innovations in extant communities of practice.

Because educator communities that depend on face-to-face meetings are time-consuming and may be too small to effect broadscale dissemination, several projects have developed Web-supported communities, such as the Inquiry Learning Forum (Barab et al. 2001) and Tapped In (Schlager and Fusco 2004). Consistent with their commitment to professional development following constructivist principles, developers suggest that such communities should have a flexible design, giving participants opportunities to evolve structures that meet their needs (Barab et al. 2004). Furthermore, evaluations suggest that such online communities function best as a follow-up to workshops or in conjunction with other face-to-face interactions (Barab et al. 2004, Schlager and Fusco 2004).

Other strategies to reach a broad number of individuals cost-effectively include simply posting curriculum materials on the Web (e.g., the Garden Mosaics and Cornell Science Inquiry Partnership programs) and giving short presentations at conferences. Garden Mosaics conducted a survey comparing implementation by educators attending one- to two-day local workshops, where members of the Leadership Team were available to provide ongoing support, with educators attending 1- to 2-hour presentations and short workshops at professional meetings. Preliminary results suggest that educators attending longer-term local workshops are more likely to implement activities with youth than educators attending short-term conference presentations (table 3). Furthermore, educators attending longer workshops with follow-up support were more likely to implement the in-depth investigations, whereas educators attending short presentations were more likely to use the simpler "Science Pages" (table 2). However, the fact that 83 percent of the educators attending the shorter-term presentations who responded to the survey either conducted or planned to conduct activities with youth (the survey was conducted only a few months after the workshops and presentations) indicates that such short-term strategies do have some impact. It may be that the individuals attending the professional conferences had more resources and education (factors associated with follow-up) compared with the educators targeted in the local workshops, many of whom were from community organizations with limited resources, high staff turnover, and irregular youth attendance.

Conclusions

Despite the emphasis on ongoing professional development and support in the social-learning literature, preliminary results from surveys of educators attending Garden Mosaics workshops (varying in length and follow-up support), as

Table 3. Implementation rates of educators attending local, in-depth workshops and short conference presentations in the Garden Mosaics program.

Implementation	Number (percentage) of positive responses	
	Local workshops[a]	Conference presentations[b]
Implemented some part of Garden Mosaics program	8 (53)	7 (37)
Plan to implement it in the future	12 (80)	13 (68)
Implemented the program or plan to implement it in future	15 (100)	16 (84)

a. Fifteen of the 33 educators attending local workshops responded to the survey.
b. Nineteen of the 47 educators attending conference presentations responded to the survey.

well as communications from people who obtained program materials over the Web, indicate that some educators will use materials with little or no support from the program developers. These findings suggest that it is important to examine the interaction of a suite of factors in determining whether and how programs are implemented. For example, programs that may be readily implemented with little ongoing support are those that include charismatic curriculum materials, that focus on ideas compatible with the values of the intended users, that can be easily adapted to multiple settings, and that target teachers with rigorous science backgrounds and with access to computers and other resources. In contrast, complex programs and programs conducted in low-resource settings may need to plan for extensive, ongoing professional development and support of educators.

Often university faculty unquestioningly apply the expert-driven model of dissemination associated with Cooperative Extension to K–12 outreach, and thus assume that if educators receive information generated by university faculty, they will change their practices. However, the use of a model developed for agriculture in K–12 settings flies in the face of the fact that scholars have questioned its effectiveness in education, and that education and large-scale agriculture differ along a number of dimensions related to policy, funding, audience, and the nature of new practices (NCDDR 1996, Louis and Jones 2001). Furthermore, it could be argued that, unlike schools and nonformal educational settings in which opportunities for sharing practices are limited, Cooperative Extension operates in a context of ongoing communities or networks of university researchers, county agents, and farmers interacting with each other on a sustained basis. In fact, the lack of emphasis on such communities in the innovation-adoption literature may be in part because functional communities of practice among farmers were already in existence, and thus were taken for granted.

The preliminary model proposed here can be used by both program designers and researchers. University faculty or other program designers can use the model to reflect on the factors they can control (their own commitment and skills, the innovation being introduced, dissemination strategy, and goals for dissemination) and those over which they have relatively little control (educators and their context). They also can collect information about the educators and their context, so that they can design innovations and dissemination strategies that are aligned with educators' interests, skills, and organizations. A researcher seeking to better understand factors affecting dissemination could use the model and accompanying questions as a guide for collecting information on existing programs, and for testing hypotheses about the effectiveness of different interventions. For example, at Cornell, we are embarking on a research project to compare the effect of the interaction of factors related to educators (e.g., skills, access to computers) and dissemination strategy (educators attending a hands-on workshop versus using a training DVD) on the number and quality of programs implemented. Results from this and other research can be used to refine the proposed dissemination model and to suggest ways to improve K–12 outreach efforts.

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