CREATING AN ACADEMIC HOME FOR INFORMAL SCIENCE EDUCATION

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Two days of discussions at “Public Institutions for Personal Learning: Understanding the Long-Term Impact of Museums,” demonstrated clearly that there are university and independent researchers, practitioners, and funders eager to create and carry out a research agenda for nonformal learning. The variety of compelling research questions proposed, the richness of the research methodologies suggested, the eagerness to use the results of that research, the interest of funders – argue that there is a potential community that should get its act together and begin this important work.

The individuals who assembled in Annapolis, however, came from sectors that are normally separated, geographically and professionally. Most attendees had never met the majority of their fellow participants. Attendees belonged to sectors that do not share a common journal, professional organization, or specialized language of research and practice.

One reason for this isolation of professionals with a deeply shared interest is the lack of any academic center for informal (or nonformal) science learning. University departments traditionally support academic rigor, research teams, scholarly journals, symposia, and the other apparatuses that advance a research field. For informal science education to become a *discipline* it is probably necessary and certainly desirable to create at least one academic center. This function is not currently being filled by any university, at least in North America. A center for informal science learning could fill a serious void by providing the nexus for academic research and publications to sustain the rigorous study. The center could also serve to train leaders for the rapidly growing field of museums, science-technology centers, zoos, aquariums, community activity centers, and multimedia and mass-media educational enterprises. This paper describes the rationale and some of the essential characteristics of such a center.

Questions for a New Industry

Informal science learning is a billion-dollar industry. In North America alone there are more than a thousand science museums, natural history museums, zoos, aquariums, children's museums, and botanical gardens. Science, medicine, and natural history programs on television have crossed the boundary between noncommercial and commercial channels. You can get a scout merit badge in astronomy or ecology or geography. Science and math courses for families are offered in community centers around the United States.

But this kind of science learning opportunity differs from the formal school classroom in many ways. There are no grades and no tests. Frank Oppenheimer, founder of the Exploratorium in San Francisco, was fond of pointing out that nobody can flunk museum. Because there is no required attendance, participants must be attracted, lured into these learning experiences. Many informal learning experiences are flashy, exciting, advertised, and noisy.

How effective is the informal science education enterprise? Do the people who create and operate this enterprise know what they are doing? Do they have a theoretical base, or at least an agenda on the table, for examining what they are doing and why? Is there some training program for people in the field so that they start with a basic knowledge of what the field is, what it knows, and what it needs to learn?

The answers to all these questions are “we don't know” or “we are not sure” or simply “no.” These are all issues that, in a field like physics or formal school-based education, would be handled by the academy. University programs have professors, postdocs, undergraduate and graduate students, books, peer-reviewed journals, research seminars, and dissertations. These mechanisms make sure that research and evaluation, theory, study agendas, vigorous debate, and a common knowledge base are pursued by an ongoing community with shared knowledge.

Is the Academy Ready to Help?

At least in North America, there is no academic home for informal science education. To be sure, there are a few dozen university faculty members, several of whom attended the Annapolis Conference, who are attempting to provide some of these components of a research establishment and who have been doing important work. In addition to the conference participants, Chandler Screven in Wisconsin, Stephen Bitgood in Alabama, and Ross Loomis in Colorado are among the important scholars in the field. But there is no *center,* no critical mass of activity sufficient to support, for example, a stable, refereed journal of informal science learning.

There are programs in science communications, reviewed recently by Lewenstein (1994). These programs are primarily targeted at journalists and writers and do not offer regular study of museums, zoos, botanic gardens, or science-technology centers. Museum studies programs exist at over a dozen universities in North America, but they are focused on art and history museums and on the collections aspects of natural history museums, not on the informal learning of science and technology.

For a few years in the 1970's an academic center for informal science learning did exist. It was at the University of California at Berkeley, and was called SESAME (Search for Excellence in Science and Mathematics Education). This interdisciplinary program, which offered a Ph.D., brought together faculty from science, engineering, cognitive psychology, and education; students were required to have strong backgrounds in science and technology. Dissertations included research in cognitive theory and evaluation, often in settings such as museums, zoos, and aquariums. There were exciting seminar series and, if not a refereed journal, at least a stream of articles published in various scholarly journals.

The program thrived for about ten years, a period during which several of the faculty were particularly interested in informal (rather than formal) science education. Those faculty have since retired or moved to other universities, and the program today is concentrated more traditionally in studies of cognition and formal education. But during the brief period when SESAME served as the academic home for informal science education, it and the nearby school of education at Berkeley produced perhaps half of the most often cited students of the field (Judy Diamond, John Falk, Jeff Gottfried, Cary Sneider, Mark St. John, and Sam Taylor, for example), including more than a dozen of the directors and senior staff of today's science museums and science-technology centers.

In the absence of an academic center, many of the dispersed scholars who pursue the field of informal science learning are attempting to produce and finance a journal and have held a half-dozen conferences, most recently in London and Albuquerque, devoted mostly to visitor studies. Thought-provoking papers do appear, but there is rarely a sustained debate that carries an issue long enough for consensus to emerge.

The Need for Research and Evaluation

The lack of a research center is holding back the entire field. Most informal science institutions have no ongoing research and do little summative evaluation. In response to demands by foundation funders, such as the National Science Foundation, institutions of informal learning may hire one of a dozen consultants to do a brief study at the end of the project. This contact is too casual and peripheral to establish a habit of reflection or rigorous self-questioning.

The need for research and evaluation in informal science education cannot be overemphasized. We do have excellent studies of the impact of individual informal science learning experiences. A recent publication edited by Crane (1994) provides the best available summary of these studies and what has been learned from them. Yes, people do learn science from some of their experiences within museums, from watching films, and from participating in community activities. And we know how to improve the effectiveness of those experiences, whatever the relative effectiveness is at the beginning. Most impressive is how effectively informal science education projects have used formative evaluations. Any given aspect of a program can be and often is measurably improved. An exhibit at the New York Hall of Science is a case in point.

In the first prototype of a computer-based exhibit unit on the human immune system, the HIV virus, and AIDS, visitors navigated through sections on anatomy, invasion of the body by various forms of germs, and the body's elaborate defense mechanisms. Each section featured written and spoken text, colorful cartoon-style graphics, animation, and sound effects. A key goal of the exhibit unit was to address certain potentially fatal misconceptions about HIV, such as the notion that any form of birth control provides protection against infection. Once the biological characteristics of this virus's infection route are understood, it becomes apparent that only condoms or abstinence provide protection.

The exhibit designers wondered if the highly stylized representations of the human body, which had been used in an earlier, more general exhibit about the human immune system, would remain adequate for this very serious treatment and more focused exhibition. More realistic drawings might prove more effective, but might also draw visitor complaints.

Formative evaluation demonstrated that the new exhibit unit failed to make much of an impact on the widespread misconception about the ability of all contraceptives to prevent transmission of the disease. A more explicit depiction of intercourse was tried, and while still not approaching photographic realism, this version did significantly improve visitor understanding. Twice as many visitors left with the correct understanding of the relative efficacy of condoms versus other means of birth control in preventing the transmission of the virus. For example, correct answers to one question on condoms versus diaphragms rose from 22 percent to 45 percent of visitors tested (Falk and Weiss 1993).

While formative evaluation has repeatedly produced valuable results like these, the state of summative evaluation and generalizable results are much shakier. Even when the numbers of subjects are large, as in the audience for a television show or an exhibition, informal science education practitioners have been faced with the same problems of evaluation that bother formal education: the "treatment" experienced is not identical for every individual; the control audience can rarely be matched satisfactorily with the experimental audience; and in practice we measure only a tiny part of the potential effects, cognitive and affective, of a program.

A great deal of effort has been expended in such summative evaluation efforts as determining whether a planetarium or a classroom experience is the better communicator of astronomy. Yet it is not likely that comparative effectiveness questions can be posed in a way to yield any information of general utility.

So do participants in informal science learning become more effective and happier citizens, workers, and parents? We don't know. But then we don't know if formal education produces more effective and happier citizens, workers, or parents.

In understanding education, informal education in particular, we are in a state more comparable to astronomy in the days of Ptolemy than the days of Isaac Newton. We have lots of data on the individual entities (exhibit units, television shows, family math sessions), but no general rules that apply from one experience to the next or can be applied in devising a new program. Predicting the success or failure of an informal education project is a poorly practiced art. Even worse, we cannot learn much from our mistakes. We rarely build a second version of that exhibit or a remake of that film.

First we need to know what we do not know about this enterprise. Then we must decide what we need to know. For example, among the issues raised at the Annapolis Conference were:

- Who participates in each of the forms of informal science learning, who does not participate, and why?
- How do adults support and discourage learning by children in a museum?
- What elements of the museum experience occur regardless of the discipline presented?
- What do visitors expect when they come to a museum, and is learning one of those expectations?
- What is unique about museum-based learning?
- What is the cumulative effect of years of museum visits on an individual? On a community?

To begin to answer these questions, careful and sustained collection of anecdotal evidence and satisfaction surveys can be useful, especially for uncovering the critical questions to be asked. Then we need to expand our research and evaluation studies to cover a broader range of experiences, rather than the project-by-project, exhibit-by-exhibit, film-by-film studies that we have done to date.

Miller's (1991) ongoing longitudinal population studies are a start, even though informal education is treated only sketchily in his work. This type of study needs to be supported and extended to cover broader experiences and broader communities.

Does Informal Science Education Matter?

The goal of an institution like the New York Hall of Science is to change visitors. They should be different when the leave the museum. We would be happy if they learned something during their visit, but we would be even happier if we knew that they were more inclined to learn something after their visit.

Frank Oppenheimer liked to tell the story of a woman who called up to tell the Exploratorium that after a visit she had repaired a table lamp for the first time in her life. He explained that although there was not a single exhibit in the Exploratorium that would be directly relevant to repairing a table lamp, somehow experiencing the hands-on exhibits had given this visitor the confidence to try a technical task on her – even if working with 110 volt wiring might not have been the safest apparatus for a beginner to try.

Affective changes can be measured. Television commercials, for example, are evaluated not merely by how many people watch them, or what viewers learn about the product, but by sales of the product in subsequent weeks. In the year after a temporary exhibit on insects is presented by the New York Hall of Science, is there a rise in the sales of books on insects at the Barnes and Noble chain? A rise in the number of visitors to the insect display at the zoo? An increase in the circulation of insect books at the New York Public Library? An increase in viewers for the insect film on NOVA? More girl scouts earning the insect merit badge? Of course there will be many confounding variables that will make any such changes based on the presence of one exhibit in one museum difficult to interpret. But if the study is broader, dealing with multiple topics treated by informal education programs in many cities, patterns may begin to emerge.

What does change the visitor or viewer or participant? The program itself may be only a small part of the experience. What about the social dimensions of the experience: how the visitor interacted with staff, gift shop items, or other visitors? Are all happy museum experiences alike in some ways? Are all unhappy museum experiences alike in some ways?

The long-term impact of informal science education should appear not only in continued informal learning but in such measures as enrollment in science courses in secondary and higher education. Successful experiences in informal science learning as children should be reflected in increased participation in lifelong learning opportunities at universities and continuing professional training in science and technology industries.

Devising a research agenda of sufficient scope is not going to be easy. There is the fear of failure and the subsequent drying up of funding not only for research but for the informal learning enterprise itself. There is the lack of research infrastructure: it is hard to sustain a research program without an academic center for such research, with its tireless graduate students, refereed journal, and provocative seminar series. But we cannot continue to sell informal science education to foundations and the public if we do not try. And our competitors who place entertainment first, and education a distant second, like Disney and the most of the mass media, have a long head start on us in understanding how to sell sizzle with the merest promise of nutritional benefit as an added bonus.

The Need for Leadership Training

Academic centers traditionally become the primary supply mechanism for leadership in a field. For those of us who administer informal science education institutions, the lack of a training center for leaders in the field is felt most keenly.

At the New York Hall of Science, which like many other science centers has been growing rapidly, we are in the process of recruiting several senior staff. To find well-prepared leaders who are familiar with the field, we will have to raid the staffs of other institutions. After all, in the past seven years our small staff has been raided several times, and at least two museum directors and the director of exhibits at a much larger institution have come from our tiny original staff. Beyond that, we know we will have to hire people with no familiarity of the world of science-technology – people who must undertake the leadership of multimillion-dollar projects and learn the context and details on the fly.

How serious is this lack of leadership training? In 1971, when the Association of Science-Technology Centers (ASTC) was formed, there were 17 North American institutions that qualified for membership. Today there are 240 institutional members, many created in the past decade, and there are 46 “developing” institutions, preparing to open their doors (ASTC 1992). In the most recent comprehensive survey of the 240 institutional members of ASTC, 179 institutions reported an aggregated full-time-equivalent staff of 14,530 (ASTC 1994).

A separate study (St. John and Grinell 1993) counted developing or recently opened science centers, natural history museums, zoos, botanic gardens, aquariums, and children's museums, and came up with 199 institutions. These institutions are in the process of finding directors, exhibit directors, education directors, project managers, evaluators, and fund raisers. If half of these institutions eventually reach the average 81.2 full-time-equivalent staff members of the reporting ASTC institutions, the field will have grown by eight thousand new employees.

The concern for the preparation of staff for informal science education extends beyond the institutional employers themselves. The science research community views the low level of public understanding of science with alarm. If informal science education institutions continue to be the major source of learning outside of school, the staff of these institutions must set and maintain standards of quality and scientific integrity in their public programs. A source of staff trained in science and science communications becomes all the more necessary since economic trends in the informal education sector are encouraging recruitment of many staff from the entertainment and service marketing industry.

We look not only for experienced, qualified staff; we would like to find a diverse staff, representative of the broad public we would like to serve. Over 70 percent of the 160,000 school-age children who visit the New York Hall of Science each year are members of minority populations. Since the field is relative young and is growing rapidly, informal science education could be creating an industry with *visible* equal opportunity at every level, including the executive offices. But without a prescribed career route, without brochures advising young people of the exciting jobs available, without the top-notch training and placement service available at a university center, informal science education presents a subterranean profile, especially for minority students who may be the first generation in their family to attend college. A look at the directors of museums in the United States will reveal that racial and ethnic diversity is essentially nonexistent.

Descriptors of a Center for Informal Science Learning

What would an academic center fulfilling these needs for research and leadership training look like? Here are some key features:

■ an interdisciplinary faculty with several full-time-equivalents, with expertise in science, psychology, and education and in addition regular participation from departments of business, journalism, economic development, and the arts, such as theater, film, and graphic art

■ a respected base within the university structure. Schools of education should be significant partners, but their sometimes arm's-length relations with the “hard” science faculty and the poor reputation of K_12 science education today might mean that a program based solely in the school of education would have a harder time placing its graduates than would an interdisciplinary program within the division housing physics, chemistry, and biology research.

■ degrees at the master's and doctorate level, and perhaps a minor at the undergraduate level. Strong preparation in fundamental science and technology must be co- or prerequisite at all levels.

■ intimate ties with informal science education institutions, including several close enough to provide daily research settings and part-time employment for students in the program. “Real world” experience, through practicums, internships, and thesis work in these institutions will greatly enhance the employment opportunities for students.

■ sufficient seed funding to support visiting professorships, seminar series, publication, conferences, and travel for faculty. Once the program is under way and producing leadership for the field, the opportunities to place students, the demand for admissions, the grants from the National Science Foundation and private foundations, and the requests for consulting contracts will make the program one of the more self-supporting interdisciplinary efforts of the home university. But it will require a couple of years and incubation funding to launch the program.

Outline for Curriculum

A curriculum for research and leadership staff development for informal science education should include courses in cognitive psychology, science education, museum studies, and exemplary practice in the science center field. The outline which follows was developed from discussions with leaders in existing museum studies programs, schools of education, and informal science education institutions.

■ cognitive and learning theory and criticism: Piaget, Brunner, Karplus learning cycle, naive theories, Gardner

■ information theory: signals and noise, Shannon, Wiener

■ research and evaluation methodology: qualitative and quantitative research design and methodologies, front-end, formative and summative strategies and practical techniques

■ history and practice of informal science education: museums, science-technology centers, film, mass media, electronic media, community-operated programs like Scouts, 4-H, Girls Inc.

■ relations with formal education: teacher preparation and professional development, K_12 curriculum development, enrichment programs, American Association for the Advancement of Science's Project 2061, National Science Foundation's systemic initiatives

■ nonprofit institution funding and administration, including board and government relations

■ project development and management, including ethics and intellectual property issues

- sector-specific skills, such as exhibition planning and design, multimedia production, and on-line technology

- interdisciplinary skills: the role of the arts, humanities, and sciences in creating public programs in science

- practicum or internship at an informal learning institution or related enterprise

Coming Soon to a Campus Near You?

Several universities are considering programs like the one described in this paper. There are in many places tenured, mid- and late-career faculty in need of a new field in which they can be reinvigorated and can excel. Universities just below the top tier in their realm are seeking programs in which they can be the world leaders. Even if those programs are relatively modest in size, moving up the university-prestige ladder means having undisputed leadership in several areas, and the well-established fields like physics and literature are hard to crack.

What will be needed are a few academic "stars" to give the new venture respectability from the start and a few angels or powerful senior administrators to fund the start-up costs. There are no assurances of success, but there is a new industry in search of leadership. There are important questions to be answered in how democracy can prepare its participants for an age of science and technology. And somebody will get to be the Newton of informal science learning.

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