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Science Centers in a New World of Learning

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Abstract

By creating new media channels that enable anyone to reach the public directly, the Internet has reduced the need for a "middleman," resulting in the "disintermediation" of science communication. In addition to sources online, new providers of informal science learning are emerging in community settings. These changes raise the critical question of how science centers can adapt to a growing ecosystem of mediated and unmediated sources. This article points out strengths of science centers that offer some grounds for optimism. Promising efforts are identified and possible directions are proposed at the community and institutional level.

It is not surprising that the environment in which science centers operate has changed dramatically since the Association of Science-Technology Centers (ASTC) was established in 1973 with 16 founding members. The rapid expansion of the field since then is reflected in the more than 600 ASTC member institutions today (ASTC 2012). That growth has been accompanied by major demographic, societal, environmental, and technological changes. The implications have been addressed in several reports (Merritt 2008, Ferrell and Medvedeva 2010). This article will explore how science centers might respond to this changed environment, with emphasis on the impact of new platforms for science communication.

Disintermediation and New Means to Reach the Public

The information technologies that created the computer and the Internet have had, and continue to have, enormous economic impact that disrupts traditional ways in which businesses have operated. Digital media and the Web have made possible new channels for nearly ubiquitous communication. The result in many cases has been "disintermediation"—consumers able to interact directly with suppliers, eliminating the need for "middlemen" such as bookstores. Most pertinent to science centers, the Internet now makes it possible to obtain information, products, and services of nearly any kind directly from any source, both professional and amateur. One of the outcomes is the deinstitutionalization of education (Semper 2007).

In the case of science and technology, direct "unfiltered" communication often takes the form of blogs, such as *ScienceBlogs*, "where the world turns to talk about science" (http://scienceblogs.com/). In addition to its invitation-only collection of blogs, this "digital science salon" has reputedly become the

largest online community dedicated to science. Technorati, a blog search engine, includes in its directory some 12,000 science blogs and 37,000 technology blogs. YouTube enables researchers to directly post online videos such as one from the GRASP Lab at the University of Pennsylvania (Kushleyev, Mellinger, and Kumar 2012) that has been viewed more than six million times after going "viral." Vodcasts and podcasts on STEM topics are available directly from their originator (for instance, RadioLab) or through aggregators such as iTunes. Other sites—such as Futurity (http://www.futurity.org), created by a consortium of major universities—share research news directly with the public. In addition, the public can now participate with scientists in cutting-edge research through online citizen science projects such as EteRNA (http://eterna.cmu.edu), which offers biweekly competitions that allow online participants to design new ribonucleic acid molecules. The winners actually get synthesized in the laboratory by the scientific team and tested in further research.
The Web has become the primary source by which the public now finds information about science (de Semir 2010).

These and other means for scientists and engineers to reach public audiences directly were examined in a recent National Academy of Sciences colloquium on the "science of science communication" (Ucko 2012). Its focus was empirical social science research designed to inform scientific experts in their communications with the public. Notably, little explicit mention was made of informal learning in general, or science centers in particular.

New opportunities for informal science learning are emerging within communities, as well as online. In the New York City area, for example, the Science Festival Foundation produces the World Science Festival, a multi-day series of activities featuring a variety of programs and performances. The Imagine Science Film Festival presents a weeklong showcase of science-based films. On a smaller scale, the California-based not-for-profit organization Iridescent conducts inquiry-based science and technology programs for underprivileged students and their families in an impoverished section of the Bronx. Other groups, such as Secret Science Society and Nerd Nite, offer lectures and programs. Crowd-sourced informal courses are offered by Brooklyn Brainery. Individual entrepreneurs, such as the woman known as "Science Teacher Sarah," offer afterschool programs, birthday parties, and day camps.

The publication of *The Experience Economy* (Pine and Gilmore 1999), more than a decade ago, marked the then-emerging trend in which businesses use props and services in order to engage customers. Since then, stores have emerged that exclusively sell experiences. An example is Make Meaning, in which "Associate Creativity Enthusiasts" (ACEs) guide children and adults in craft-based "creative experiences." A similar approach has been taken recently by Storefront Science, which offers open science exploration for an hourly fee, as well as after-school science clubs, weekend, and summer programs; it may become the first of a national franchise.

Individual scientists still continue to reach the public through more traditional means. In a recent survey, 21 percent of academic biologists and physicists who responded indicated that they participate in outreach efforts that engage the public through such activities as public lectures or writing books for non-specialists (Ecklund et al. 2012). Nevertheless, these scientists still perceive significant barriers to outreach at an individual level, within their institutions, and from the general public.

A Basis for Science Centers to Respond

This new environment provokes a question: How can science centers adapt? Will they follow a downward spiral, like place-based retailers that are being eclipsed by the Internet? Or will they be able to respond in productive ways that enable them to thrive? Semper framed the question as “middle-aged maturity or mid-life crisis?” (2007) while Friedman posed the issue more broadly as “the great sustainability challenge” (2007).

Science centers offer several grounds for optimism.

Learning Experiences

Science centers have the capacity to create meaningful, socially-mediated learning experiences that cannot readily be duplicated online, at home, or at school. For example, they can take advantage of the scale of their exhibition spaces by presenting large authentic objects—dinosaur fossils and space shuttles, for instance. Experiences can be immersive, placing the visitor inside an engaging setting, such as the coal mine at Chicago's Museum of Science and Industry. On a larger scale, Science City at Union Station in Kansas City, Missouri, immerses visitors in an entire “city.” Programs such as Portal to the Public, developed by the Pacific Science Center in Seattle, Washington, let visitors engage with working scientists and engineers, who share their research. Science centers can also provide a range of materials and tools, letting visitors work in a safe environment with interesting parts and equipment, such as the growing number of “maker” installations (Siegel 2012).

Through appropriate STEM-based content, these types of learning experiences have the potential to motivate the visitor's “system 1,” the fast, emotional, and intuitive aspects of thinking as well as engage the slower, rational “system 2” (Kahneman 2011). To be most effective, their design should be informed by learning research (Fenichel and Schweingruber 2010, Leaper 2011). They should be intrinsically motivating (Perry 2012), in contrast to the Mary Poppins approach (“a spoonful of sugar helps the medicine go down.”) Integrating learning with enjoyable socially mediated experiences enables science centers to reach audiences who may not be ready to pursue science online. However, science centers have traditionally categorized their activities as exhibitions or programs, rather than informal learning experiences. Eliminating that distinction may foster the development of new approaches that do not fit neatly into those two categories and may help address the question of whether exhibitions have a future (McLean 2007).

Technology

Since most visitors attend with family members, classmates, or friends, the experiences at science centers are social. Technology has created social media systems that enable visitors to share their knowledge and experiences with a wider online network (Russo, Watkins, Kelly, and Chan 2008). Technology can enhance the visit in other ways, such as augmented reality exhibits that create a virtual immersive environment (Dede 2009). Just as new exhibitions are often accompanied by supporting Web content and activities, smartphones and their “apps” can enhance and extend the experience, assuming that they are developed in ways that support the social experience (Johnson, Adams, and Witchey 2011). One possibility is “family apps” that intentionally stimulate inquiry-based learning conversations among the members of a visiting group. While in the science center, handheld devices can 1) serve as customized guides with “just in time” information, 2) provide links to social media, and 3) create “bookmarks” to aspects of interest for follow up. Furthermore, apps can enable science centers to take advantage of the new online sources created through disintermediation; layers of personalized interpretation can be added by connecting visitors to content that deepens the experience. (Open access also enables visitors who wish to challenge the authority of the science center to obtain alternative interpretation on such topics as evolution and climate change.) In this way, mobile devices can serve to "augment reality" within real science center settings. In addition, game-like apps have the potential to extend the visit almost indefinitely; they might also provide a virtual experience for non-visitors, some of whom may be enticed to visit.

Public Engagement

Science centers can enhance their community relevance through public engagement with science (PES). This term specifically describes mutual learning by publics and scientists through discourse on societal impacts of science and technology (Rodari and Merzagora 2007; McCallie et al. 2009). The Nanoscale Informal Science Education Network (NISE Net), a national community of researchers and informal science educators, launched by the Museum of Science, Boston and others (Bell 2008), created a Dimensions of Public Engagement conference and wiki (http://dimensionsofpes.wikispaces.com/). These types of activities can provide meaningful learning experiences for teens and adults (an audience largely underserved by science centers), as well as potentially valuable feedback for scientists, engineers, and policymakers. In addition, they can serve a constructive function by fostering community dialogue through such programs as "deliberative screenings" in science center theaters of films on topics that raise societal concerns (Nisbet and Scheufele 2009). Because they engender a high degree of trust, science centers can play an important role with respect to topics that have become polarized based on religious and political values. In addition, they have the capacity to frame issues in ways that respect and respond to visitor values. Simply providing more factual information, however, can actually increase polarization, enabling those on each side to believe even more firmly in the evidence that supports their values (Kahan et al. 2011).

Partnerships

Science center partnerships range from the local to the international. Science centers frequently partner with schools, universities, libraries, other museums, public media, and community-based organizations. Regional partnerships have been formed in North Carolina, Texas, California, Arkansas, and other states. Nationally, one of the most promising is NISE Net, which involves more than 100 member institutions in the shared development, testing, and adaptation of resources. Started by a handful of organizations, the Network has been growing organically and is developing an ethos of collaborative, open source creation of exhibits, programs, and materials. This model represents a major step forward, compared to earlier efforts such as the Science Museum Exhibit Collaborative, whose founding was based on shared funding among specific institutions. A related effort is the Open Exhibits initiative, which develops free, multi-touch, multi-user software (http://openexhibits.org); in its first year, it attracted a user community of more than 1500 people (Rockman et al. 2011). Partnerships such as these can provide access to audiences and resources, as well as opportunities for professional development. Networking multiple science centers and sharing resources can also reduce costly duplication of effort that results from the common practice of "reinventing" exhibits and programs at each institution.

Research and Evaluation

The growing body of research and evaluation in informal learning, recently synthesized in a report by the National Research Council (2009), provides an evidence base that can be used to create more effective learning experiences. Several factors have contributed to this growth, including coalescence of the learning sciences, additional requirements for evaluation, growing academic interest in informal learning, and maturation of the field. Initial steps are taking place to address the significant challenge of how best to assess informal learning. The Assessment Tools in Informal Science website (http://www.pearweb.org/atis/resources) has been created to aggregate and obtain user feedback on extant measures. The National Academies recently organized a Summit on Assessing Informal and

Afterschool Science Education (June 11-12, 2012) in order to begin to identify the most critical issues for moving forward. The Center for Advancement of Informal Science Education, with the assistance of the Visitor Studies Association (VSA), has developed an Informal Science Education Evidence Wiki (http://iseevidencewiki.org) and a PI Guide to Evaluation (http://caise.insci.org/activities/pi-guide), in addition to other resources for the field, such as the Informal Commons search engine (http://informalcommons.org). VSA also is creating a searchable evaluator database and synthesizing evaluation results from reports posted on the informalscience.org website and other sources. In addition to advancing research and practice, these efforts should contribute over time to demonstrating the value of informal learning, especially to those whose perspective has been limited to performance in school or on standardized tests.

Professionalization

Overall, the field is continuing to professionalize. A contributing factor has been the growing knowledge base—along with experience and intuition—that can inform practice. A field that has grown primarily through on-the-job experience in a craft-like manner is increasingly recognizing the importance of ongoing professional development. ASTC has encouraged the formation of several communities of practice in youth programs, teacher education, and public engagement, among others. The Noyce Foundation has funded a Leadership Institute through a program designed to help senior science center managers learn to act as "change agents"; the program is now working with a fifth cohort of 18 fellows. Several universities offer graduate degree programs in informal or "free-choice" learning.

A Larger Context

The learning experiences offered by science centers exist within an ecosystem of mediated and unmediated sources. These include institutions (schools, universities, museums, and libraries); not-for-profit organizations such as those identified in the Informal Science Education Landscape Study (Falk, Randol, and Dierking 2008); and individuals who are now empowered with mobile devices that enable ubiquitous learning. As part of this STEM learning ecology, science centers constitute a national infrastructure (St. John and Perry 1994). They offer "complementary learning" (see Weiss et al. 2005). As part of this ecosystem, science centers have the potential to create new models for learning and education in their communities. That role builds upon a key characteristic—self-directed learning, whose value is increasingly being recognized by education leaders (although not necessarily linked with informal learning *per se* or with science centers in particular.).

For example, the *2020 Forecast* was developed by the KnowledgeWorks Foundation as a tool for catalyzing the national transformation of education (2011). They note that "major forces of change are challenging us to realize a world of learning that puts learners at the center, leverages technologies and human capital in new ways, and incorporates new structures." They also forecast that this "world of learning" will be customized, connected, amplified, authentic, relevant, and resilient; that learners will engage in immersive and authentic learning experiences; and that self-directed and peer-based learning will rapidly expand.
Because science centers embody many of these characteristics, they are well positioned to contribute towards and help shape this vision.

The Connected Learning initiative of the MacArthur Foundation charts a similar direction. This effort was developed in response to an "urgent need to reimagine education" and to address the "ever widening-gap between in-school and out-of-school learning experiences." In language that again resonates with informal learning attributes, they note that "connected learning posits that the most meaningful and resilient forms of learning happen when a learner has a personal interest or passion that they are pursuing in a context of cultural affinity, social support, and shared purpose" (Digital Media and Learning Research Hub 2012).

Furthermore, the directions envisaged by these two foundations are supported by research from the learning sciences. As summarized by Sawyer, the most effective learning environments have the characteristics of customized learning and collaborative group learning, based on authentic inquiry-oriented projects (2008, 9). In addition, they reflect essential dimensions of informal learning: non-didactive; highly socially collaborative; embedded in meaningful activity; initiated by learner's interest or choice; and removed from external assessment (Callanan, Cervantes, and Loomis 2011).

Possible Directions

So how might science centers participate in shaping this emerging new world of learning? "What would it mean to think of education as a responsibility of a distributed network of people and institutions, including schools, libraries, museums and online communities?" the MacArthur Foundation asks (2012).

One direction is to focus outward at the community level, seeking to integrate science center learning experiences into community settings to a greater extent than traditional outreach programs. The New York Hall of Science and the Exploratorium have experimented with science exhibits installed in public locations. On a grander scale, science centers could help create "legible cities" through "social media, location based services, tagging systems for personalized content, natural user interfaces and advanced technologies such as augmented reality, data visualizations and multiplayer networked games" that make the built environment more accessible and understandable (Kuslansky 2012). This type of facilitated real-time urban exploration also provides an opportunity to "democratize science" (Fraser, Halpern, and Piemons n.d.).

Science centers have taken steps to embed facilities and programs within the communities they serve. Examples include the Taylor Community Science Resource Center of the Saint Louis Science Center and the science-focused community network formed through the Philadelphia/Camden Informal Science Education Collaborative (PISEC) (Borun, Kelly, and Rudy 2011). These types of initiatives could be extended through such activities as "open neighborhood tinkering centers," which could provide intergenerational learning opportunities, as suggested in the *2020 Forecast*. Science centers also could partner with businesses to create commercial ventures in their community, such as a hotel with a science theme carried throughout its guest rooms and public areas. A science "center" could even be decentralized completely into a series of neighborhood storefronts or programs operating at multiple sites within community organizations, creating a flexible network that reduces or eliminates the burden of maintaining and operating a permanent facility.

Another approach is institutional: breaking down organizational and disciplinary barriers that can limit the vision of a science center. For example, Science City at Union Station (Kansas City, Missouri) creates interactive role-playing "adventures"within immersive settings rather than exhibits in the usual sense (Spivak 1999). The Queens Public Library Children's Discovery Center integrates science exhibits within a library setting. The California Science Center's World of Ecology integrates animal habitats on a large scale within interactive science exhibits (with accreditation by both the American Association of Museums and the Association of Zoos and Aquariums). COSI in Columbus, Ohio has created a “center of science” by assembling under its roof scientific and educational partners that include a television station (WOSU@COSI); a working Ohio State University research laboratory (OSU Labs in Life), Battelle Laboratory's STEM Innovation Network; the Columbus Historical Society; and the STEM-based Metro High School (Cheseborough 2011).

Museum-schools, hybrid institutions that integrate informal learning activities with the formal education system, offer another model. They include the Museum School for children ages three to six at the Fort Worth Museum of Science and History; the Los Angeles Unified School District charter elementary school at the California Science Center; and the Science Leadership Academy high school affiliated with the Franklin Institute. Assuming they are able to overcome school district constraints, such hybrids can provide a laboratory setting with the potential to develop and test new ways to engage students in learning. These experiments could help science centers “evolve into full-fledged learning resource centres, and some segments of the school day might be better spent in these institutions, rather than in traditional schools” (Sawyer 2008, 10), or they could contribute to the far more challenging task of seeking to transform their partner educational system (Ucko 2011).

Another possible institutional direction is to focus strategically on a niche that responds directly to expressed community needs. For example, the concept for a science center proposed for the South Bronx is based on a “museum of me” as a personalized means to address health issues in a New York City borough ranked the unhealthiest of all 62 counties in the state (West, Ucko, and Friedman 2012). Its focus on “who am I” (Koke and Fraser 2010) would draw from research on how to influence behavior from the social sciences and public health.

As a way for organizations to recognize “informal and interest-driven learning,” the MacArthur Foundation has supported through a competition the concept of “badges” (http://dmlcompetition.net). These badges are represented by icons that learners could chose to display online. The Mozilla Foundation has created an Open Badge Backpack with embedded metadata about the learning activity and its certification. One of the competition winners was the Smithsonian National Museum of Natural History, partnering with Learning Times, to develop NatureBadges, an open source nature and science badge system. They represent one example of “lifestream technologies” that could be used to create lifelong learning logs that document personalized learning from diverse sources.

Challenges

Despite these potentially promising directions, major challenges remain. Perhaps most critical is the science center financial model, which in most cases is based on earned income, in comparison with the public funding that supports most K-12 education (ASTC 2012). That dependency leads many institutions on the costly never-ending quest for “blockbuster” exhibitions. The fixation on revenue generated by on-site attendance may also limit efforts to extend science centers deeper into their communities. The fixed costs and overhead expenses of operation and maintenance of a facility create ongoing financial obligations, which may also encourage risk aversion. Raising admission fees to generate earned revenue only further exacerbates the challenge of diversifying audiences. In addition, because the financial bottom line is connected only loosely with educational impact, there is little monetary incentive to build on educational research and evaluation. New financial models, in addition to those proposed by others (Falk and Sheppard 2006), will need to accompany the programmatic directions discussed here.

Perhaps, as optimistically noted in the *2020 Forecast*, the learning system will "create new partnerships and models for thinking innovatively about funding and about resources such as materials, physical space, and expertise" (KnowledgeWorks Foundation 2011). Strategic restructuring offers a potential set of options for science centers to establish ongoing relationships with one or more other organizations to further their programmatic missions and increase administrative efficiencies (Kohm and La Piana 2003). The restructuring could share, combine, or transfer programs, resources, or services through an alliance, such as joint programming and administrative consolidation, based on a formal agreement. Alternatively, it could lead to integration through a joint venture, such as establishing a management service organization that consolidates administrative functions; a parent-subsidiary arrangement; merger; or even acquisition.

Conclusions

As a result of several factors, such as publication of the NRC synthesis report, informal learning may be approaching a "tipping point" in external recognition of its public value (Ucko 2010). Even if that is that the case, however, there is no assurance that science centers in their present form will thrive in an environment in which change is the norm. As noted, many science centers have made promising efforts to adapt, but will that be enough?

This article has identified a number of factors that provide grounds for optimism. The focus of science centers on "learners" and the potential to engage learners in self-directed, authentic, social, and immersive experiences are major assets, particularly if they can be enhanced and extended through appropriate technology. Strategic use of partnerships and networks can increase reach, efficiency, and impact. The growing knowledge base and continuing professionalization of the field have the capacity to advance informal learning overall. Taking advantage of these affordances and approaches will strengthen the role of science centers in their communities, helping them to occupy a vital niche in the expanding STEM learning ecology.

However, it is not yet clear whether incremental change will be sufficient, especially in light of the current financial model. New community-based and institutional directions, perhaps along some of the lines suggested here, may be required. If science centers do not take the lead, disruptive innovations may emerge from outside the field—as is already taking place through disintermediation. To avoid becoming marginalized by the forces of change, science centers and the informal learning field at large must strategically forge their own future.

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