Science Centers:
examples from the U.S. and from Germany

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From the itinerant lecturers of the 18th century to popularizing physics in the 21st century –
exploring the relationship between learning and entertainment
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Deutsches Museum

Abstract. Science centers can be places of informal learning, where entertainment and learning combine. In contrast to lectures, school experiments and old-fashioned museum exhibits, visitors in science center are not forced to copy experiments, but are allowed to explore and – in the best circumstances – thereby become a true scientist themselves. Here I will dispel some misunderstandings about science centers that are often heard from museum professionals as well as from other educators. Besides some remarks of definition I will discuss two "prototypical" institutions, their philosophy and some exhibits.

Introduction

"A revolution is under way in the field of science communication."[1] The world-wide flourishing of informal learning and the shift from the deficit model to dialogue in the communication of science and the public emphasize the role of science centers and science museums in science communication. They are public places, independent and non-aligned – places that are popular and well-trusted. They are not "only" places of learning but also places of entertainment.

The Exploratorium in San Francisco and the Ontario Science Centre in Toronto opened its doors in the late 1960s (after the decade of reform in science education that followed Sputnik's launch in 1957) and count as the first exemplars of science centers. They allow people to be active rather than only to watch at show-cases. They have predecessors in older science museums, e.g. in the Deutsches Museum in Munich that was founded at the beginning of the twentieth century and shows – alongside the static historical collection – machines in motion and allows visitors to turn on exhibits, e.g. models, by a button.

In the United Kingdom, the first science centers were launched in the 1980s. A lot of science centers opened (and a lot of money has been spent for this) in the last five years in the UK.[2] Even later the science center movement has reached Germany. Today, there still is only a hand full of science centers in Germany.

What is a science center?

> Science centers and museums are environments for **informal learning**, a process central to forging knowledge, skills, and positive attitudes about science. Science centers are places to **discover, to explore, to test ideas about the natural world**. They are unique resources for families and schoolchildren, teachers and citizens. In increasing numbers, science centers are also places where people of all ages, cultures, and educational levels can learn at their own pace, engage their curiosity, and use all their senses to ask and answer questions, explore, and **explain to others** what they have learned.[3] (emphasis by MDW)

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1 John Durant: "From 'Deficit' to 'Dialogue': Some Recent Trends in Science Communication", lecture held at the Deutsches Museum, Munich, 14 October 2003.

2 Today, 90 percent of the British population can reach a science center within one hour journey time.

3 http://www.astc.org/about/scicenters/centers.htm

As one can learn from this definition by ASTC (Association of Science-Technology Centers Incorporated), science centers stand in contrast to formal education institutions. They serve everyone. Visitors do not just reproduce experiments, but they are enabled to think like scientists in their pursuit of understanding.[4] The focus is laid on phenomena as opposed to objects and processes in museums of science and industry. Last not least, science centers are no places of one-way communication but facilitate dialogue among visitors.

Science centers are distinguished from museums by there emphasis on interactive exhibits and lack of specimen collections. Whereas in the U.S. the terms "science center" and "science museum" generally are taken as synonyms, in Germany there (still) is an ideological debate about these concepts.[5] Sometimes you find attributions of bogus-features to science centers, like the following: they are supposed to engage in edutainment that has more to do with a gambling house than with school, to focus "only" on children, and to offer lots of multimedia, computer, IMAX etc. Albeit there are some institutions where those features may fit, science centers generally are places of learning, have a broad audience, and may offer electronic or new media as additional resources, but not as central didactic approach.

As it is not easy to give a definition, it is even harder to count the number of science centers worldwide. There is a great variety of aims, topics, target groups, modes of presentation, organization, funding, etc. Attempts of counting resulted in numbers ranging between 400 and more than a thousand worldwide. The upper estimates seem to include not only science museums, but also institutions like museums of local history with only some interactives.

Exhibits in Science Centers: Between Entertainment and Education

There are three features for good exhibits in science centers, i.e., exhibits that enable inquiry learning and simultaneously entertain (cf. Oppenheimer 1968):

- Parameters of the experiment can be changed by direct handling of the parts. The results can be directly observed and immediately experienced by human perception.
- The exhibits are "honest and simple": no one feels he or she must be on guard against being fooled or mislead.
- Instead of pushing button and watching always the same (like watching a videotape), it is open what happens.[6]

These exhibits are „Working Prototypes" (Oppenheimer 1986): never finished, but continuously improved.[7] Some exhibits are so successful that you can find them in a lot

4 Therefore, the concept "visitor" is understated and is sometimes replaced by "user". Admittedly, laypersons becoming scientists during their stay in a science center is only an ideal that is not at all reached by every science center: "[M]ost science centers argue that interaction is enough, but in fact exhibits rarely allow visitors to actively shape the nature of their inquiry" (Bradburne 1998, p.238).

5 For example, some people say the Deutsches Museum is at least in part a center since 1903, other warned us "not to become a science center"...

6 It can be one of the happiest moments in the life of an exhibit designer when visitors use the exhibit in an unforeseen, though meaningful way

of science centers. Actually, it is not easy to invent a completely new exhibit, and exhibit developer generally follow an incremental process: "The rule is: 'You may steal as many ideas as you want, but you should always make your own exhibit a little bit better.'" (Persson 2000, p.456).

To find out what science centers really are and what purpose they serve, it is a good idea to check prototypical, "purist" examples, i.e. science centers where glamour, exciting architecture and design, or multimedia does not overlay the original didactic approach. Here I will focus on the Exploratorium in San Francisco (especially on the role of inquiry learning) and on the Phänomenta in Flensburg/Northern Germany (especially on its relation to university science education).

The Exploratorium, San Francisco/CA

> There are two models for great American amusement centers and both can be found in California. Rising from the plains of Anaheim is the original Magic Kingdom Disneyland. To the north, in a hangar-size building at the foot of the Golden Gate bridge, is the Exploratorium. (Newsweek 1989)

The Exploratorium[8] is a renowned museum of science, art, and human perception, located in San Francisco. Physicist Frank Oppenheimer founded the museum in 1969 as a place to introduce people to science by encouraging self-discovery through a process of asking questions that lead to further understanding. A collage of over 600 interactive exhibits in a floor area of 10,000 m^2 enable this process. The Exploratorium has over 500,000 visitors/year.

Fig. 1: Interior view of the Exploratorium (Copyright: The Expoloratorium).

7 Goery Delacote (1998, p.2054), the present executive director at the Exploratorium, sees a close resemblance between the Exploratorium workshop and a research lab.

8 www.exploratorium.edu

With its exhibits, the Exploratorium offers a science curriculum appropriate for both the informal and formal teaching of science. These exhibits are also the starting point for formal teacher training and for a variety of programs for children and youth.

The starting point of the Exploratoriums philosophy says: Everybody is a scientist. "We do not want people to leave with the implied feeling: 'Isn't somebody else clever.'" (Oppenheimer 1985, p.5). A main goal is to cause surprise and interest in nature and science:

> For many people science is incomprehensible and technology frightening. They perceive these as separate worlds that are harsh, fantastic and hostile to humanity. (Oppenheimer 1968, p.206)

> If people feel they understand the world around them, or, probably, even if they have the conviction that they *could* understand it if they wanted to, then and only then are they also able to feel that they can make a difference through their decisions and activities. (Oppenheimer 1985, p.26)

In the best cases – this is at least what tales tell – the Exploratorium does not only arise interest, but visitors also come from the Exploratorium back home and wire a plug, or change a light bulb for the first time ever.

Exhibit labels at the Exploratorium are divided into three sections:

- "To Do and Notice" encourages visitors to play with an exhibit by suggesting some (but not all) experiments one might try.
- "What's going on" answers some of the questions about the phenomena, and
- "So what?" may point out the historical importance and possible applications of the experiment and the phenomena.

Fig. 2: The "Light island" enables experiments with light rays, mirrors, prisms (Copyright: The Expoloratorium).

Fig. 3: Visitors are challenged of getting the disks and rings to stand on edge while moving around the "Turntable" (Copyright: The Expoloratorium).

Inquiry, Abstraction, and Explainers

It is often stated that "hands-on" is fundamental to the philosophy of learning in science centers. But the real core of it is inquiry learning:[9]

> Inquiry is central to science learning. When engaging in inquiry, students [or visitors in science centers; MDW] describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. […] In this way, students [and visitors] actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. (NRC 1996)

Although inquiry learning is often achieved by hands-on activities, hands-on is not a necessary condition for inquiry. Take as an example (visual) perception experiments.[10] Nor is hands-on a sufficient condition for inquiry, because just playing around without reflection is a kind of "hands-on" but has not much to do with science learning.

The exhibits in science centers like the Exploratorium do generally not follow the order of science disciplines. They have no fixed place in a curriculum. Answering critique about this, Oppenheimer turned the alleged deficit into a central point for his method of learning and teaching, referring to the „woods of natural phenomena" that make up our world (Oppenheimer 1986, p.6).

> The Exploratorium is about nature, and one of the major accomplishments of science has been to demonstrate that there is a unity to the diversity of nature. (Oppenheimer 1986, p.5)

> One of the great virtues of museums [and science centers; MDW] stems from the possibility that visitors can, by themselves, achieve a very satisfying understanding, through abstraction from multiple and contextually different examples. Many museums fail to provide this possibility because they show only a single representative example of each effect or process. (Oppenheimer 1985, p.17).

For example, you will find resonance phenomena in strings, ropes, membranes, metal plates, air columns, water, etc. Resonance fits to musical instruments, electrical inductance and capacity, etc.

The students that act as floor staff are called "Explainers" – but they primarily do not provide visitors with the "right" explanation. Good explainers aren't:

> [They] embody what they encourage others to practice – playfulness, curiosity, thoughtfulness, reflection. […] [I]t's not about having all the answers; it's about being thoughtful and discussing ideas, perceptions, and possible conclusions. […] [They] help visitors build confidence in their own learning. (Librero 2003, p.6)

The Explainers are part of the educational mission of the Exploratorium in not only guiding the visitors, but also in learning more about nature and science by doing this.

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9 See Kluger-Bell (1999) for a comparison of inquiry to other learning techniques.

10 "In many of the best interactives, the action is all in the visitor's head" (Beetlestone 1998, p.7).

Phänomenta, Flensburg/Northern Germany

The Phänomenta[11] has come into existence around 1985 as a product of research of the Institute of Physics and Education at the University of Flensburg. It started with exhibits inside the university location. Today, the Phänomenta presents 150 interactives on 1800 m². The city of Flensburg benefits from the Phänomenta as a highlight for tourists and since 1993 provides a building for free. About 70,000 visitors come to the Phänomenta every year. (That is quite a lot if you take into regard that Flensburg is a small town at the border between Germany and Denmark.)

The Phänomenta regards itself as an institution between museum and amusement park. It has to generate its income from admission charges, shop and workshop (selling exhibits to other institutions). Since 1990 a foundation supports the science center. This foundation has also established science centers (Phänomentas) in other German towns (Bremerhaven, Lüdenscheid, Peenemünde, Templin) and intends to expand further.

The Phänomenta doesn't offer explanations on floor or labels, because this instructive information would inhibit individual learning. The function of labels is to suggest and to inspire own experiments. But for those who are eager for knowledge (after the individual learning), a book is offered to be worked with after the visit (Fiesser 1998). With this, visitors can re-think their own experiences and are provides with "correct" scientific descriptions, explanations and historical background. But, however, the own experience is regarded as primary.

Close relationship to university

The invention, development and optimization of interactives, serving the visitors and investigating the learn-effectiveness are the main topics of research at the Institute for physics and didactics of physics at the University of Flensburg. Students from the University of Flensburg are hired to take care of the visitors at the Phänomenta. As the Explainers at the Exploratorium, they primarily don't offer explanations but enable visitors to explore themselves. By doing this, the students gain experiences that are useful for their later job as teacher, and they especially qualify in informal learning. The students do not only interact with visitors at exhibitions, but there is also a program – "Young researcher's club" – where the students advise and coach a group of kids working on their own science projects. This kind of events complements the field of exhibition.

Many ideas arise from the institute and are implemented in the course of the student's master theses. In some projects, students are responsible for most of the stages in making an exhibition from the first brainstorming through the implementation and to public relations.

Summary and perspective

Although there were predecessors in science museums already around 1900, it was not before the 1960s and 1970s that in the U.S. (and decades later in Germany) science

11 www.phaenomenta.com

centers came into existence. They popularise physics and other science disciplines by letting the people experiment themselves – experimenting in a truly interactive way and not only pushing a bottom and then watching what happens.

Phenomena in science centers are to be explored in many and individually different ways. This stands in contrast to many experiments in school or school labs, where students are forced to repeat "experiments" under the guidance of cookbook-like recipes. Therefore, science centers can play an important role as places of learning complementing school.

Today, the outlines between science centers, traditional science museums, museums of natural history, children's museums, zoos, aquariums, theatre (!), and other places of informal learning blur. Hybrid[12] and expanded[13] forms, that utilize specific strengths of various forms of presentation, may become important places of learning and entertainment in the future.

References

Beetlestone, JG et al.: 1998, The science center movement: contexts, practice, next challenges, *Public Understanding of Science* **7**, 5-26.

Bradburne, J: 1998, Dinosaurs and white elephants: the science center in the twenty-first century, *Public Understanding of Science* **7**, 237-253.

Delacote, G: 1998, Putting science in the hands of the public, *Science* **280**, 2054-2055.

Fiesser, L: 1998, *Wie war das noch...?* (Exhibition Catalogue of the Phänomenta), Flensburg (Germany).

Hein, H: *The Exploratorium: The Museum as Laboratory*, Washington.

Kluger-Bell, B: 1999, Recognizing Inquiry: Comparing Three Hands-On Teaching Techniques, in*: Inquiry – Thoughts, Views, and Strategies for the K-5 Classroom* ("Foundations" vol. 2 by the Division of Elementary, Secondary, and Informal Education; NSF 99-148), 39-50.

Librero, D: 2003, Playful Attention: The Role of the Explainer, *ASTC Dimensions* Jan/Feb., 6-7.

National Research Council (NRC): 1996, *National Science Education Standards : Observe, Interact, Change, Learn*, National Academy Press.

Newsweek: 1989, Playgrounds for the Mind, *Newsweek 25 July 1989*.

Oppenheimer, F: 1968, 'A Rationale for a Science Museum', *Curator* November, 206-209.

Oppenheimer, F: 1985, *The Exploratorium* (Special Issue, March 1985).

12 E.g., the Deutsches Museum (Munich, Germany) always was such a hybrid in mixing historical objects, machines in actions, models, interactives and media. Science museums in general today integrate more and more interactives into their exhibitions. On the other hand, classical science centers like the Exploratorium are now integrating historical objects.

13 E.g., science theatre and science shows shown in museums.

Oppenheimer, F: 1986, *Working Prototypes*, San Francisco.

Persson, P-E: 2000, Science centers are thriving and going strong!, *Public Understanding of Science* **9**, 449-460.