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Science Centers: A Potential for Learning

Science centers are educational institutions designed around informal learning activities.

Lee Kimche

Summary. The past decade has witnessed a proliferation of science-technology centers, or public places for informal learning about science and technology. Science centers are the only institutions that can provide the general public with participatory exhibits and experiences, together with an accurate scientific interpretation of the materials that are involved. The dramatic rise in attendance and the enthusiasm of repeat visitors to science centers reflect a strong public demand for exhibits designed to help the visitor develop a better understanding of the contemporary scientific issues of society.

Science centers provide a whole new field of self-motivating experiences in learning, through environmental exhibits that appeal to the senses, emotions, and intellect. They are among the most rapidly developing institutions of learning in contemporary society. They have been responsive to a growing public demand for knowledge and information. As more and more people visit them, the science centers have a unique opportunity to assist a large segment of the public to gain a greater understanding of the contemporary technological issues of society. The objects and exhibits can form the basis for other types of educational programs, not only within museums, but throughout the entire community. The informal educational techniques that science centers employ may have implications for other types of institutions. Traditional forms of education are undergoing reappraisal; perhaps some of the methods used in science centers can be adapted to enhance more conventional methods of teaching.

The growth of science centers began early in the century. The greatest growth has occurred within the last 10 years, and there is no sign that the trend will slow down soon. The expansion of existing science centers is proceeding apace with the building of new facilities.

Attendance Explosion at Science Centers

The increasing number and size of science centers is a direct result of the sharp rise in public demand on existing institutions. The number of visitors to science museums is greater than to any other single type of museum. According to a 1974 survey of 1820 institutions conducted by the National Endowment for the Arts (*1*), 38 percent of all museum visits were to science museums, 24 percent to history museums, and 14 percent to art museums. The survey, which included natural history museums in the science museum category, found that, of a total of 308 million museum visits in FY 1971–72, 117 million were to science museums. Excluding natural history museums, science-technology centers alone have experienced skyrocketing attendance in this decade, with the 14.4 million visits registered in 1973 soaring to 36.5 million in 1975. And in 1976, more than one-fifth of the members of the Association of Science-Technology Centers reported attendance increases of at least 10 percent since 1975. Many science centers that offer after-school, evening, weekend, and summer courses have reported waiting lists for enrollment, and still other museums have been forced to impose time limits at certain participatory exhibits due to long waiting lines.

Until recently, it was thought that science centers appealed primarily to children. It is true that school groups form approximately 25 percent of visitors to these centers, but a brief survey shows that 45 percent of the visitors are adults, including college students and senior citizens (*2*).

Most full-scale science-technology centers offer workshops for all age groups in chemistry, biology, photography, ham radio operations, computers, magnetism, model airplane construction, and other popular fields. Classes and workshops for school-age children reveal some intriguing offerings, such as "Elementary, My Dear Watson: Solving Problems by Deduction," "Marble Shoot Computers," "Water Wizardry," "Optical Toys and Parlor Amusements," and "Performing Plants." Although fewer programs are offered for adults, they range from auto rally classes to lapidary labs, from workshops on dehydrating foods to "Wild Parties," banquets based on edible wild plants (*3*).

Characteristics of Science Centers

Most other kinds of museums have evolved as depositories for categorical collections that may be admired by the public and studied by scholars in private. While traditional museums emphasize static displays of objects and artifacts,

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science centers have followed the more dynamic philosophy of the Chinese proverb: "I hear and I forget, I see and I remember, I do and I understand."

Studies by Thier and Linn (*4*) revealed that visitors are not attracted to science centers to learn only facts; they come to experience new and interesting phenomena. This is substantiated by a preliminary study by Yankelovich (*5*) at the National Air and Space Museum. Fifty percent of the visitors in the museum, when asked why they visited the museum, answered "for juicy tid-bits"; 40 percent said that they came for entertainment or a dynamic experience; and 10 percent cited miscellaneous purposes.

Attendance at science centers is voluntary, unlike the required attendance of most traditional educational programs, and the course that the visitor follows once inside is self-established. There is no "required" reading, listening, or viewing. There is no prescribed path to be followed, or set time for departure. In the museum, visitors may spend as much time as they want at the exhibits that interest them most. Goodman (*6*) has stated that people will learn best when they have opportunities to make choices about their own learning and chances to build on their own interests. In a study of children between the ages of 10 and 12, Thier (*7*) found that they showed an interest in exploring science materials of their choice, and that self-selected science experiences foster the development of logical thinking in that age group.

A museum is a social environment, and learning takes place more readily in a social context. One reason that people go to science museums is to share time with family or friends. According to Laetsch, who is director of the Lawrence Hall of Science in Berkeley, family groups constitute the museum's single largest constituency, and his research has shown that adult-child combinations spent more time at the exhibits selected for observation than did child-child or adult-adult combinations (*8*). Almost no research has been done on learning in family groups, yet the museum is perhaps the only educational setting where families frequently appear as a unit.

Another feature of science centers is that they provide experiences that are not available anywhere else. Increased technology has brought about an increased desire among people to do things in simulation that they cannot do in actuality.

Through the modern, sophisticated technology found in science centers, the public is able to experience more activities on a firsthand basis. In addition to simulated submarines and airliners, many science museums offer the public opportunities to use telescopes, computers, musical instruments, and other apparatus to which few people have access elsewhere. The instructional design of such exhibits as the "Physics Playground" at the Exploratorium in San Francisco is one of the more innovative approaches to informal learning to be found anywhere. There, swings and other playground equipment were constructed to teach the principles of physics.

People go to science centers to satisfy their curiosity about branches of science that are having more and more impact on their daily lives. The public is demanding timely access to information on subjects such as the saccharin debate, genetic engineering, nuclear reactors, solar energy, air and noise pollution, food supply, and other critical issues. Science centers are peculiarly adapted to presenting this material understandably. Few of these issues were publicly evident when many people completed their formal education; the science center affords access to authoritative information in a setting where people can keep abreast of new developments in science and technology voluntarily and on a lifelong basis.

The learning opportunities available at science-technology centers comprise a resource that can be understood best in the context of a change in public attitudes toward formal and informal education and leisure time. A survey of high school graduates' satisfaction with their educational achievements during the past 10 years since their high school graduation showed that 46 percent were dissatisfied with their intellectual accomplishments (*9*). This would partially explain the findings of Hyman (*10*) that indicate that 50 million adults are currently engaged in pursuing some form of continuing education and that only 9.6 million of those adults are enrolled in programs that lead to a degree or other certification from an educational institution. The remaining 40.4 million are involved in courses, classes, symposia, and discussion groups that are provided by other institutions, such as museums, libraries, businesses, community groups, religious organizations, and science-technology centers.

Furthermore, science centers present information on current issues objectively since their goal is to present enough facts to enable people to make intelligent decisions on their own.

Special constituencies such as the deaf, the blind, women, senior citizens, inner-city youth, and non-English speaking immigrants and tourists are finding that science centers have been among the institutions most responsive to their needs.

Opportunities for Educational Research

Relatively little information exists from which to determine whether the experiences that people have in science centers actually result in measurable advances in learning. Research to date has concentrated on gathering demographic data about museum audiences and on exhibit popularity, rather than on the effectiveness of exhibits in transmitting information. Both cognitive and affective testing of museum experiences are limited because the traditional instructional model that is employed in pedagogical research is inadequate to measure the effectiveness of museum experiences.

Furthermore, if learning in a museum is a visual and kinesthetic experience, which differs qualitatively from sequential classroom lectures or reading printed texts, recent theories of brain physiology should also be taken into consideration (*11*, p. i). Current experiments have found that this distinction has a somatic basis, that is, the hemispheres of the brain have distinctive behavioral attributes (for example, visual learning is right-brained, while linguistic-based information-transfer is left-brained). If we are to maximize the potential of learning opportunities in museums, it is imperative that new models for measurement be developed. These models should be based on the uniqueness of the museum experience and take into account the most recent theoretical and empirical studies of the brain.

A systematic measurement of what people get out of a visit to a science center, or how, if at all, they are changed as a result of the visit, is just getting under way. The few researchers who have pursued this question are divided over the question of whether or not such changes are even measurable. It is possible to measure information transfer in terms of cognitive gains by testing how much a person can do, or how many questions he can answer correctly, before and after exposure to a given exhibit message (*11*–*13*). But if the results of the cognitive testing are disappointing, the value of the visit should probably not be written off without knowing anything about the affective or attitudinal impact of the visit. As long as evaluation of the museum experience is carried out with methodologies designed to measure cognitive gains, or the quantity of information absorbed, the danger exists that museum exhibits will fall short of their potential to be inspirational and provocative stimulators of ideas as well as transmitters of knowledge. New evaluation tools need to be developed that can meaningfully register the museum-goer's attitudes and feelings, not only about science but about the informal learning environment itself. Photography is not a measurement tool, yet one only has to look at photographs of people interacting with exhibits for evidence that something more than information transfer is taking place. Systematic tools need to be designed that can interpret what the camera has always been able to capture: laughter, concentration, perplexity, satisfaction, curiosity, surprise, awe, and the thrill of discovery. Tressel has suggested that one of the most important accomplishments of a museum visit is to provide people with reference points that can aid them in later reasoning (*14*). It may be impractical to collect data on the recollection of museum experiences days, weeks, months, or even years after a visit, or on how recollections are triggered; but it is evident that mention of a particular science museum will make eyes light up, nostalgia creep in, and people respond, "I will never forget my childhood experiences at the Museum of Science and Industry," or "I practically grew up in the Franklin Insitute."

Screven pointed out in his studies that "learning cannot be directly observed. It must be inferred, usually from observed changes in what a visitor can do before and after exposure to an exhibition" (*13*, p. 68). How much visitors learn depends on the time and effort they devote to an exhibit, as well as on an exhibit's content and layout. Therefore, it is useful to distinguish between the "teacher-learning" aspects of an exhibition (what an exhibit potentially can teach or communicate) and its motivational aspects. Motivation involves exhibit conditions (contingencies), which determine whether the visitor will stop, spend time and effort attending to content, return, and so on (*15*). Effective teaching exhibits should integrate both learning and motivational aspects.

Shettle found that the average visitor views an exhibit unit for 20 seconds and tours a complete exhibit for a maximum of 14 minutes (*12*, p. 38). If both observations are correct, it may be concluded that science centers are able to draw the attention of the viewer for a very limited, if concentrated, period of time. In order to capitalize on that time, it is important not to require the reading of extensive text nor concentration on visual aids that would try the patience of the average viewer. To create such learning systems, Screven has added various interactive response devices to permanent exhibits, such as cassette tape recorders linked to punch cards, game cards, or free-standing self-teaching machines. His data suggest that the added interactive devices improve visitor learning (*13*). Screven also found that casual visitors in both art and history-science museums can then be motivated to spend time and effort at exhibits to achieve specific learning goals, and will learn considerable substantive content in the process (*13*, p. 69). Much more work needs to be done to develop and expand the more effective use of these methods to meet the practical and everyday demands of museums.

Science centers have been forerunners among educational institutions in introducing participatory experiences which provide effective but informal learning techniques. The findings of Laetsch, Screven, and Shettle correlate well with the theories of many educators who have found that learning is enhanced when the learner is involved in self-discovery (*16*). Involving the learner in what is to be learned is an approach basic to science centers. Shettle studied the educational and attitudinal impact of exhibits and stated that "active participation heightens the acquisition and retention of information" (*12*, p. 40).

The concepts of "visitor involvement" and "participatory exhibit" have undergone some basic changes in recent years as a result of museum research on viewer attention span and of nonmuseum research on cognitive and affective processes. The earliest exhibits deemed participatory were those in which the role of the viewer was limited to pushing a button which then activated the exhibit on a fixed course, started a tape recording, or lit up a panel bearing a printed message. Thus, the push-button variety of exhibit was considered an early mode of viewer participation.

With the advent of systematic exhibit evaluation, the participatory nature of push-button exhibits fell into dispute. Eason and Linn explained "the term participatory does not refer to exhibits equipped merely with start buttons or audio tapes. Participatory exhibits actively involve the visitor in discovering information through his own participation in the demonstration process" (*16*). In a more recent study, Borun found that push buttons correlate negatively with learning, and that successful participatory learning devices are those that allow manipulation, experimentation, and variation (*11*, p. 67). Laetsch, in attempting to determine the essential properties for an instructionally efficient and effective exhibit, concluded "some feedback loop between the person and object appears to be necessary" (*17*).

Currently, push-button exhibits are considered first-generation participatory exhibits. In this context, an attempt to improve upon the push-button exhibit and correct its deficiencies has resulted in the development of exhibits that provide for viewer dependent variation. Many of these exhibits are in the form of self-teaching machines, which offer a number of advantages over their push-button predecessors. They are equipped with several buttons instead of one, and may offer the viewer an opportunity to select the button that he thinks is appropriate in response to a series of stimuli. Often the visitor will be asked by the exhibit to select the correct answer to a question from a multiple-choice set of responses, and usually the exhibit will give immediate feedback on whether the answer is right or wrong. This method seems to have some success in helping visitors to learn (*13*).

The inclusion of feedback mechanisms into exhibits would appear to be, as Laetsch has claimed, essential if the object is to maximize learning. People tend to repeat a behavior when positive reinforcement is given; Shettle has found that people tend to discontinue a behavior when no reinforcement is given as well as when negative reinforcement is given (*12*, p. 40).

While Shettle has demonstrated that interactive devices improve learning (*12*), it must be remembered that he is referring to on-the-spot learning and to the learning of a finite amount of information contained in the instructional format of the exhibit. Others have suggested that while automated exhibits may increase the likelihood of learning some things, they actually limit the potential for learning many more things by designing all but a few possibilities out of the exhibit. Self-teaching machines allow choices, but from a preestablished set of alternatives. They do not allow an opportunity for raising questions other than those raised by the machine, or for learning information other than that transmitted by the machine.

Moreover, it has been demonstrated that mechanical devices and moving parts are not necessary to render a participatory experience. "A tree has no pushbuttons or gadgets attached to it. But one can look at it, lie under it, climb it, feel it, study the bark and cambium layer and root hairs, extract sap, learn about photosynthesis, hear the rustle of the leaves, and watch the sway of the branches," says Oppenheimer (*18*).

Many science centers make use of live animals in their exhibits and educational programs. Laetsch has found that live animals have more attention-holding power than any other kind of exhibit except computers, each averaging 15 minutes. Other types of exhibits surpassed in holding power by the live animals were passive displays (30 seconds), push-button-activated devices (2.5 minutes), puzzles (5 minutes), and games (5 minutes), including noncomputer self-teaching exhibits (*8*). Neither a tree nor a goat has push buttons, nor does an iguana or a rabbit have gadgets attached; yet one can feel, hold, or feed a goat or rabbit, examine its coloring, observe its behavior, and speculate upon the structure and function of its anatomy as an adaptation to its natural habitat. Thus, one is moved to ask more profoundly, "Why does an iguana have thick skin?" or "Why do a rabbit's ears differ from those of a cat?"

If participation is enhanced by maximizing accessibility to an object and its intrinsic features, can trees, animals, water, sand, and prisms be called third-generation participatory exhibits? The addition of interpretative devices to models representing these natural objects and materials may facilitate viewer learning, but it does so at the expanse of reducing the viewer's range for discovery.

The possibilities for learning through participatory exhibits seem to be endless. But the possibilities for measuring what is learned have not even begun to be realized. One can learn the color of animals or the height of trees from a book or lecture or film. But manipulating a live rabbit or tree, or operating a real computer, produces more than a knowledge of its physical properties; it produces affective responses, and it is these affective responses that so far have not been measured adequately. Goodman has noted that it is important to address the "whole person" in any education endeavor. In addition to the cognitive realm, it is crucial that we acknowledge and focus on the affective (*6*).

Oppenheimer argues that the attributes of participatory exhibits, "their beauty, their multiple linkages with different themes, the inclusion of extraneous possibilities for intervention and discovery, have proved important to the overall effectiveness of the museum" (*19*, p. 33). He sees most of the exhibit pieces at the Exploratorium (San Francisco) as links in a pedagogical chain, with many links common to several different chains. Thus, the Relative Motion Swing, which has a swinging table beneath a pendulum on the same period, can be used in many contexts. "We can use it in talking about vectors, polarized light, Lissajous figures, phase, amplitude and frequency, damping, kinetic and potential energy, frame of reference, and relative motion" (*19*, p. 31). Chase, after conducting a museum study on the environment, states "objects that allow tangible, direct, personal and complementary experiences . . . are most meaningful when they are linked to other components of the museum learning environment" (*20*).

To carry these findings to a logical conclusion, if the cognitive and affective experiences gained by the museum visitor can be linked to the internal and external experiences that occur in everyday living, then the informal kind of learning that is possible in museums is invaluable. It becomes important to understand ways in which opportunities for learning in the museum can be enhanced by appropriate linkages to other learning environments, as well as ways in which learning in other environments might be enhanced through appropriate linkages to museums.

Conclusion

Little data have been collected to prove that the experiences that people have in science centers are educational. Two factors suggest that the potential for learning in science centers is great. (i) The dramatic rise in attendance during the past decade and the enthusiasm of repeat visitors reflect a strong public demand for science centers to provide exhibits designed to help the visitor develop a better understanding of the contemporary scientific issues of society. (ii) Objects housed in the museum form the basis of alternative, participatory educational programs. Museums are the only institutions that can provide the general public with these kinds of participatory experiences, together with an accurate scientific interpretation of the materials that are involved. The interaction of these two factors—the predisposition on the part of the visitors to be receptive to the museum's message, and the capability of the museum to transmit the message in a multisensory and yet authentic manner—indicates the presence of conditions favorable to learning.

Although no conclusive data exist, it can be deduced from available research that exhibits can be considered an educational medium, but that new evaluation models must be developed. The present educational and anthropological evaluation models that have been imposed on the science and technology center environment are inadequate. To ascertain the full potential for learning in science centers, systematic data must be gathered about the characteristics and effectiveness of the informal learning environment offered by science centers. Methods for collecting evidence that are not dependent on the exogenous variables that each visitor brings to the science center environment must be devised.

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