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ABSTRACT

Presented is a discussion on the value of science and technology centers in providing learning experiences for visitors. The discussion is not limited to science centers but includes applications possible to any museum interested in providing interactive experiences. (SA)

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The Value of Interactive Learning Experiences in a Museum

by

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THE VALUE OF INTERACTIVE LEARNING EXPERIENCES IN A MUSEUM*

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Introduction

Science and technology centers are organized environments in which learning can take place. They have a unique characteristic when compared to the school, the other major learning environment in our culture. The visitor (the potential learner) is there by choice and it is this choice which makes the center a unique learning environment. School visitation groups approach a trip to a center as a special event and so arrive with more initial interest and motivation than they probably feel at school each day. When visitors arrive, the center can reinforce its uniqueness by providing many program choices. Our references to science and technology centers in this paper can be applied to any museum that wants to provide and/or emphasize interactive experiences.

Of course, upon arrival visitors can choose whether they want to learn anything during their visit. They could, for example, eat hamburgers, drink cokes, and/or run up and down the stairs all day, decorate the walls or walk through so fast that they don't even have time to stop in the center store. Most visitors, however, have at least some interest in what the center contains, and how it is presented will have a significant effect on how much the individual really tries to learn and how much he or she actually learns. For the purpose of this paper we will categorize

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opportunities for learning in a center on a continuum ranging from exhibits you look at, read about, and/or hear about, to actual science experiences where the potential learners are actively involved in manipulating equipment and materials and coming up with ideas or answers for themselves. Attractions, that is, exhibits with lights, buttons, or bright colors to catch the visitors' attention, fall somewhere between these extremes. It is important to note that buttons or switches that turn on the sound or what you are supposed to read, do little to actually change an exhibit into an interactive experience. Dramatizations, working models, and other active ways of presenting ideas to an observer are different from exhibits, but are not truly interactive experiences.

Visitors are not attracted to science centers to learn facts, they come to find out about new and interesting phenomena. At any rate, there is no reason to be concerned that visitors will leave a science center feeling that they have not confronted enough facts. Our concern must be with whether the experience stirred the visitors' interest and whether, as a result, they will return to the center.

When individuals interact with apparatus they gather a different kind of evidence than when they hear or read about something. The interactive learner manipulates objects, explores variables and utilizes the evidence obtained in reaching a personal conclusion about the situation investigated. For example, children's knowledge of the physical world is gathered largely through interaction with real objects. Children who believe that heavy objects sink encounter a learning experience when they find two objects of the same weight, one which sinks and the other which floats. Verbal information about the same subject is much less likely to change a child's belief. For the purpose of this discussion we will refer to all experiences which are potentially interactive as activities. These activities include machines, carrels, and manipulative exhibits.

Science and technology centers are not schools and they do not need to be like schools. Nevertheless, they can be places where people learn. Aspects of science centers which make them potentially of great importance include: 1) people come to science centers and museums generally by choice; 2) people choose activities at centers suited to their own needs; 3) centers can provide opportunities for individuals to interact with materials that might not otherwise be available; 4) centers can alert the interested public to information about advances in science not likely to be available elsewhere.

In developing both regular school programs and enrichment activities for children we have gained a lot of information about interactive experiences. Evidence from our investigations is relevant to the design of science center activities for two reasons. First, we have evaluated the effectiveness of interactive experiences for teaching important scientific concepts and thinking skills. Second, we have investigated what happens when school children are allowed to choose their own science activities from a wide selection of possible choices.

In this paper we will (1) present evidence from a variety of areas which illustrates the effect of concrete experience on learning, (2) discuss the usefulness of personalized learning, (3) consider attitudes towards interactive experiences, and (4) discuss the relevance of these findings to the design of science center experiences.

Learning from Interactive Experiences

A variety of evidence is available concerning the effect of concrete experiences on learning.

Piagetian Theory

The work of Inhelder and Piaget (1958) implies that a program which emphasizes concrete experiences could influence the child's understanding of scientific thinking. Inhelder has stated that "Cognitive development stems essentially from an interaction between the subject and his environment. In terms of successful training procedures this means that the more active a subject is, the more successful his learning is likely to be." (Inhelder, Sinclair, & Bovet, 1974, p. 25.) Inhelder and her collaborators point out that experience which is in conflict with the child's predictions for the outcome of a particular event is an important factor in the acquisition of knowledge. Using a cognitive conflict approach with concrete experiences in an interview format, they show that many children's logical skills can be improved. The other major factor that predicts success from this training is initial performance level. In these studies extensive individual interviews are used to measure initial ability. While small interview-based studies can control for ability in assigning training, this is not possible in science centers or even in most schools.

Evidence from the Science Curriculum Improvement Study

Summative evaluation of the Science Curriculum Improvement Study (SCIS, 1974) project has demonstrated the effectiveness of materials-centered science in developing scientific thinking. In the SCIS Program for the schools the individual participates in a group oriented program of interactive experiences. Similar small group exp iences could occur in science centers.

Linn and Peterson (1973) demonstrated that the Material Objects unit (SCIS, 1970) was effective in fostering logical skills in six and seven year olds. Students of Material Objects were better able to classify objects, explain why things float, and describe the properties of objects, than comparable children in regular science classes. Linn and Thier (1975) assessed children's ability to explain a compensation after being shown the effect of the two relevant variables. They found that fifth graders (age ten to eleven) who had experienced Energy Sources were better at explaining the compensation than were comparable students in regular science programs and, in addition, that the success of students of Energy Sources approached that of eighth graders (age thirteen to fourteen) in the same school system. Bowyer (1975) evaluated the effectiveness of experiencing all twelve SCIS units. Using several rural school districts in Michigan, she compared students who had used SCIS during their entire elementary school career with students who had attended neighboring schools that did not use the program. She found that students of SCIS had a better understanding of variables, were better able to criticize experiments designed by others, and had a better understanding of relative position, solution, evaporation, and energy transfer than students who did not use SCIS. In summary, these three studies of SCIS reveal that experiential science programs are better than traditional book-oriented programs at fostering scientific reasoning and logical thinking. This is, perhaps, not surprising since it is a goal of SCIS and may not be the goal of other programs. It is, however, noteworthy that very few attempts to teach logical thinking have been successful and nearly all successful programs have involved the use of concrete experiences (Case, 1975; Anderson, 1965;

Inhelder, Sinclair, & Bovet, 1974).

Learning by Doing

As Hawkins (1965) pointed out some time ago, one must "mess about" in science to learn to do science. It follows that learning during interactive instruction differs from learning during passive instruction. Design of effective museum activities must consider these differences.

Clearly, improvement in skills such as bicycle riding, nail hammering, or computer programming can only come through interactive experience of these activities. A demonstration machine with a lens and beam of light is far superior to a book if you wish to learn to focus and bend light. Other types of learning lend themselves to different approaches. A movie, for instance, might be an appropriate way to learn about the migratory patterns of birds. Thus, science center activities designed to teach a visitor to do something must provide the visitor with the facilities to do whatever he is supposed to learn.

Adult Learning

For many years it was assumed the great majority of older adolescents and adults could learn in a much more formal way. That is, it was expected they were able to handle verbal abstractions, see relationships, and in other ways exhibit what Piaget calls formal reasoning. Recently a large number of studies have been carried out on older adolescents and adults in order to measure their formal reasoning ability in regard to science. The work of Dulit (1972), Jackson (1965), Keasy (1970), Lovell (1961), and Lunzer (1965), all showed that the great majority of the older adolescents and adults performed at the level of concrete operations on the Piagetian tasks. In summarizing this work and the work of others who devised their own tasks related to formal reasoning, Levine and Linn (1975) state, "It seems clear that concrete experience is a valuable aid to learning at all stages of adolescent reasoning." Concrete experience is also likely to be an aid to learning in the science center environment.

Usefulness of Personalized Learning

Personalized Instruction

Science centers and other museums do not have to be like schools. In the free choice atmosphere of the center the individual can decide what he wants to work on and if it proves uninteresting, too difficult or too easy, the individual can change to something else. Users can adapt activities to their needs by their own actions. Research on what happens when students are allowed to choose their own activities is, therefore, very relevant to science center activity design. Activity designers need to know what sort of information is likely to help visitors choose appropriate activities, what sort of information needs to be presented along with the activities, and what type of learning is likely to take place in a choice environment.

We have been researching these questions while designing a program of personalized "free choice" activities for the schools. Our conception of personalized activities are apparatus-based experiences with a definite starting point: Where the user goes from the starting point is completely open. Participants are free to choose whichever activity interests them from a wide selection.

Personalized interactive experiences are likely to have educative value because learners can choose to work on something which interests them. The assumption is that children given a wide range of choices in a well organized framework will choose to carry out investigations at their own intellectual level. Inhelder, Sinclair, and Bovet (1974) achieved this sort of a match between the individual and an activity by extensive individual interviews to establish the child's intellectual level. Personalized activities can be designed to depend on the users to follow a course of action which is intellectually stimulating and hopefully causes them to choose experiences commensurate with their abilities.

The Personalized Instruction Project based at Lawrence Hall of Science was designed to determine whether children could choose their own projects, work at their own intellectual level, and develop their scientific reasoning ability. The first major study carried out by the project (Linn, Chen, & Thier, in press) revealed that an introduction to science concepts (based on SCIS) followed by free experimentation with objects was well received by students and resulted in student gains in scientific reasoning ability. From the results of this study, it appeared that the introduction to science concepts was helpful to the children in structuring their experiences in the free-choice sessions.

Of importance to work in science centers, it appeared that a fairly structured introduction for each set of apparatus was useful. Free choice was not enough, without instruction students were unable to explain that they wanted to "work with chemicals" or "grow plants." Once presented with apparatus, the students looked to leaders or peers for suggestions about what to do. In general, students did not pursue independent investigations on their own (Linn, Chen, & Thier, in press). In a second study (Linn, Chen & Thier, 1975) we provided instructions for carrying out the first experiment with each set of apparatus as shown in Figure 1. Children were free to choose any one of 45 different experiments. Children who completed an experiment were confronted with up to three challenges. The challenges were offered without instructions. In this case, students were able and willing to carry out investigations, and even invent challenges of their own without leader help. We also found that children would work at their own intellectual level, were very interested in the program, and made some progress in scientific reasoning. This appears to be one way to provide interesting, enjoyable experiences in a choice environment which fosters scientific thinking in young people.

Students in this program chose which activity they wanted to pursue but were given instructions about how to begin. We found that once the student was familiarized with a particular set of apparatus the student became able to carry out independent investigations and learn from his experience. These findings are particularly relevant to the design of activities in science centers.

Personalization in the Science and Technology Center

The format of providing some materials, a problem to solve, and then some further challenges using the same or similar materials is easily adaptable to the science and technology center. By providing a wide variety of possibilities, visitors can freely choose that which they find of interest. For example, an evaluation of two formats for interactive optics exhibits at Lawrence Hall of Science revealed that both formats resulted in increased knowledge about optics (Eason & Linn, 1975, in preparation). The booth format (where subjects were invited to manipulate lenses and mirrors) resulted in greater ability to focus a beam of light at a particular point. A machine format (where subjects could only manipulate a dial which rotated a lens or moved a mirror), resulted in greater ability to explain specific optics concepts. An additional result of interest was that subjects spent nearly twice as long (about ten minutes) working in the booths as they did observing the machines.

Science center activity design is most effective when accompanied by some form of evaluation. This need not be a large scale impersonal procedure carried out by someone designated as an "expert". Rather, informal, responsive, useful procedures can be used by activity designers to gather information relevant to design revision. This sort of feedback has been called formative evaluation because it is concerned with the form of the product. Questions that could be answered include: Can the visitor read the printed directions? Are the instructions comprehensible for the target audience (generally a person who reads at about sixth-grade level)? Does each part of the activity work? How many users can profit from the activity simultaneously? What do members of the target audience do when confronted with the activity? What do members of the target audience say about the activity during and immediately following exposure? How long do visitors spend at this sort of activity? Do any visitors complete the suggested sequence of steps?

Answers to the sort of questions relevant to formative evaluation are then used to revise the activity. If, for instance, visitors generally spend less than a minute at a particular activity then written material that takes five minutes to read would be ignored. When the optics activities at Lawrence Hall of Science were subjected to formative evaluation, it was found that visitors could not utilize effectively the apparatus as first constructed due to the interference of room lights. Canopies were built over the activities so that visitors could easily see the beam of light from the light source. Additionally, diagrams for one activity were found to be far too complex for any visitor. These were simplified and drawn more clearly. These problems must be solved before the general effectiveness of an activity can be established. Frequently, however, activities are designed, built, and installed without any formative evaluation. The success of any interactive activity (which depends on reliable reproduction of observable events) requires that formative evaluation take place.

Thus it appears that interactive experiences are interesting to visitors and are able to impart information. The format of the interactive experience determines to some extent the type of information that will be learned. Formative evaluation is critical for the success of interactive experiences. Every member of an activity design team can participate in evaluation activities. Cost of activity evaluation is minor compared to its impact on the success of the activity. Formative evaluation should be an integral part of activity design rather than an afterthought.

Current emphasis on accountability in federal agencies has increased interest in evaluation. It is important to take advantage of this interest by designing evaluation procedures which provide necessary information. Some developers of programs for schools have profited from this emphasis by carrying out field trials for their materials. By also starting with the learner in evaluating activity effectiveness, science centers can benefit from evaluation procedures.

It should be noted that formative evaluation is only one kind of evaluation that is useful in science centers. Very often it is helpful to compare the effectiveness of various activities and to determine the kind of learning that takes place in a center. Traditional evaluation approaches have grown out of the agriculture-botany concept of a controlled experiment. Just as new approaches to learning in science centers are being developed, so new approaches to evaluation are needed. Levine (1974), for example, has suggested an approach based on the judicial model to aid researchers considering educational problems.

Preference for Interactive Experience

So far we have tried to discuss and analyze what the potential learner is capable of doing and there is significant evidence that concrete experience is valuable at all ages. More important than the learner's capabilities is what the learner is interested in doing. In the science center, as opposed to school, visitors are there because they choose to come. They make decisions about how to spend their time and whether they want to return primarily on the basis of their own interests. There is quite a bit of informal evidence regarding the interests especially of mature individuals who have at least some desire for learning. For example, many communities and school systems run adult education programs and almost invariably the first courses filled are the experience-related ones. Craft and skill-oriented classes are in highest demand and are usually followed by courses like typing or accounting where someone wants to learn a skill. The enormous growth in recent years of public interest in adult education crafts and hobbies is indicative of the commitment of the population today.

Most science educators and curriculum developers agree that the young learner needs concrete experiences in order to develop an understanding of science. Evidence for this is the fact that no publisher in the United States offers an elementary science program that does not have at least a closely related group of experiments or activities pupils are expected to do. Worldwide, as illustrated in UNESCO reports (Thier, 1973) and curriculum guides from various countries, the emphasis is on real experience for the young learner. At all ages' interactive experiences are of interest and value to both learners and those responsible for designing educational experiences.

Conclusions

In order to increase the understanding of science and technology by the general population, science centers need to design and evaluate programs and activities of interest to individuals on a continuing basis. All evidence, both research and informal, indicates that such programs need to have a significant interactive aspect. In this way, the individual investigating a question related to science can choose to become involved. If the goal of a science center is to teach facts, then lectures, films, books, and exhibits with lengthy explanations are the most efficient way to present a lot of information in a short amount of time. Any visitor to an exhibit hall can see that visitors do not usually choose to give their time to the verbally-oriented exhibit, book, lecture, or film. Instead, there is a huge crowd around the computer terminals, people are waiting in line to try the Tower of Hannoi puzzle, and groups are arguing about which of several kinds of birds have a beak most similar to a chisel. Non-interactive instructional procedures often offer facts about science but do not help the visitor gain an understanding of the nature and process of science. Research is needed on ways to more effectively develop and evaluate interactive experiences for science and technology centers. The special role of the science center which differentiates it from the school affords the opportunity to create something new rather than recreate the school.

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Picture Captions

1. Computers that play games with visitors at Lawrence Hall of Science.
2. Visitors using computer terminals to play games provided by Lawrence Hall of Science or devise their own programs.

   Photo by Lynne D. Calonico
3. Example of interactive exhibit at Lawrence Hall of Science. Visitors are playing a dice game which illustrates probability.

   Photo by David Best
4. Example of non-interactive button pushing exhibit at Lawrence Hall of Science: Electrolysis Machine.

   Photo by David Best
5. Student designing and building a kite in interactive workshop.
6. Student experiencing the Science Curriculum Improvement Study.
7. Students participating in Personalized Science Activities.

   Photo by Herbert Thier
8. Students participating in Personalized Science Activities.

   Photo by Herbert Thier
9. Example of directions for personalized science activity.
10. Participants in Biology Laboratory for Lawrence Hall of Science visitors.

    Picture by Charles Frizzell
11. Participants in Biology Laboratory for Lawrence Hall of Science visitors.

    Picture by Charles Frizzell
12. Group of teachers learning to build interactive equipment for children.

    Picture by John Quick