Abstract

The goal of this study is to help exhibition designers incorporate interactivity into their exhibits. In order to do this, we propose **a model of interactivity** that can be used to generate concept sketches for exhibits in a broad range of subjects, and we demonstrate how this model may be applied in designing exhibits for African-American children. Our model accounts for **task, visitor motivation and cognitive mode**, looking at two alternative ways an exhibit could account for each of these components. The relative benefits of each alternative are explored and a design model which intersects task, motivation and cognitive mode in a three-dimensional matrix is proposed. This matrix yields eight distinct ways to design an interactive exhibit. In order to demonstrate how this model can be applied to design exhibits for African-American children, we present case studies illustrating some of the possible uses.

A Conceptual Model of Interactive Exhibits for African-American Children

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Introduction

Exhibits in African-American history museums usually consist of artifacts and graphic displays. Interactive exhibits are rare, even while they are becoming commonplace in children's museums, science and natural history museums — and in places like Chicago's Shedd Aquarium. Interactive exhibits provide museum visitors with physical learning activities. They are operated and experienced, not just viewed. During the past twenty- five years, interactive exhibits have demonstrated the power to attract children, hold their attention and stimulate conversation.

The museums best known for popularizing interactive exhibits are the Boston Children's Museum and the Exploratorium in San Francisco. In the late 1960s, Michael Spock introduced interactivity at the Boston Children's Museum in a landmark exhibit called "What's Inside?" (Edeiken, 1992). His goals were to stimulate curiosity and motivate learning, recognizing play, exploration and make-believe as important learning modes.

The Exploratorium was founded by Dr. Frank Oppenheimer in 1969 and encouraged individualized learning through direct personal experience (Delacôte, 1993). In typical exhibits, children learn about molecular movement by experimenting with a hot air balloon, or about physical motion by experimenting with a small catapult that launches a marble at varying trajectories (Hipschman, 1980). The concept underlying the Exploratorium is that experience lies at the foundation of scientific understanding. The museum provides experiences which stimulate scientific interest, fosters a "can-do" attitude and concretizes outside instruction.

Exhibits in the Children's Museum and the Exploratorium do not depend on historical artifacts, are relatively cheap and can be made inmodestly equipped museum workshops. Both museums have been wildly successful, each spawning a new generation of similar institutions.

Ideally, interactive exhibits complement school instruction, which in this country relies mostly on formal methods: lectures, textbooks, written exercises and standardized tests. One failing: schools provide few concrete examples about how the principles that they teach apply to the real world. Interactive exhibits, on the other hand, can give encapsulated experiences that serve as anchor points for more abstraction instruction. When a teacher describes trajectory in a lecture on physical motion, a student might say: "I did that in an exhibit at the science museum." There is good evidence that children remember interactive exhibits more than others (Tukey, 1992). Concrete references are easiest to understand and function as building blocks for further learning.

Interactive exhibits are not without controversy. Shorthand (1987) states: "Children have fun... but they learn little science and acquire a good many misconceptions which at the very least fail to match [the conceptions] offered in the captions." On a more positive note, Davidson, Lee and Hein (1991) testify that interactive exhibits attract children and capture their attention and that children are learning in the process: "Our studies indicate that under the right circumstances, visitors are clearly able to synthesize information from many different sensory modalities into personal learning that they can articulate to an interviewer."

Museums know that interest and attitude are major factors in education. The best students develop enough interest in a subject that they learn about it on their own. Interactive exhibits may foster positive attitudes by providing positive experiences that children relate to specific subjects.

Mihaly Csikszentmihalyi describes positive experiences in terms of "flow" activities. Flow activities satisfy the following criteria (Csikszentmihalyi, 1990):

- Focus on a goal. Participants perform a task with a clear aim in mind.
- Provide appropriate challenge. The task at hand is neither too difficult nor too simple.
- Develop skill. Participants build expertise while doing/acting.

- Provide consistent feedback. Participants can see they are approaching the goal and that their skills are developing.
- Provide control over outcome. Participants can affect how things turn out.
- Engage totally. The activity commands the participants complete attention during the time it is performed.

In our experience, Csikszentmihalyi's flow criteria provide essential checkpoints when refining an exhibit design, but are not particularly helpful in generating initial concepts.

African-American museums

African-American museums are social-historical institutions whose mission is "rooted in the tragedies that haunt Black social experience in America, tragedies that obscure our history and separate us from ourselves, that pervert our cultural expressions and devalue our ancestral heritage and legacy." (Caither, 1989) African-American museums provide visitors with a sense of culture, history and the heroism of uncountable women, men and children who — while shaping their own lives — have contributed to the whole fabric of the nation. These museums contribute to self knowledge — a vital prerequisite for well being.

Some of the African-American museums are concerned primarily with art, and others with the interpretation of an historical site. Still others resurrect history in a way that makes us rethink old assumptions. Many of these museums are dominated by the task of collecting and preserving art, artifacts and historical documents — things of invaluable cultural importance which are in danger of being lost forever. All African American museums conduct educational programs and interpretative exercises and nearly all engage in publication.

Why is interactivity important for African-American museums? In interpretive exhibits, interactivity can augment significant artifacts by explaining workings and processes. Interactive exhibits travel well, because they are relatively cheap and do not require original artifacts. Interactivity can help relate history to things in everyday life and stimulate career interest by emphasizing ties to many disciplines.

A conceptual model of interactive exhibits

Design problems almost invariably involve compromises. Often a number of (sometimes radically) different designs all function as viable solutions to a given problem. Eating utensils are a good example. Orientals eat with chopsticks. Westerners use a knife and fork. In Africa and most of the rest of the world, people eat with their hands, while in the Arabic world, people eat from a communal plate. Each way of eating works well within its social and utilitarian context, and no single way is clearly superior.

The practical range of solutions to most design problems can be conceptualized as a "solution space." In this section, we propose a simple model which describes the solution space of interactive exhibits.

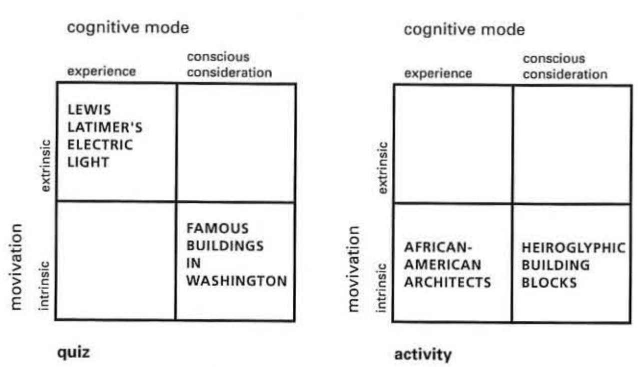
Boisvert and Slez (1995) have developed a conceptual model for exhibits based on whether concepts are simple or complex, whether the presentation is abstract or concrete and whether there is a low or high amount of interaction. This is a model of exhibits that may have important implications for designers. Their work differs from ours in that they are involved with evaluation, while we focus on design — nevertheless all of us attend to interactivity.

Successful exhibits must fulfill three criteria. They must attract visitors, hold them a sufficient amount of time and engage their attention before learning can take place (Wolf, 1985). These criteria are consecutive. It's impossible to teach visitors without engaging their attention, or to hold visitors' attention without attracting them first. Boisvert and Slez also report that interactive exhibits are effective at holding visitors and engaging their attention.

In order to attract, hold and engage visitors, a conceptual model of interactivity should center on museum visitors. After all, interactivity is about how people relate to the world. In this paper, we focus on three key visitor related considerations: cognitive mode, task and motivation. We visualize each of these considerations as two components, resulting a 2 x 2 x 2 matrix of interactive exhibits. The following sections describe each design consideration in detail.

Figure 1

Our conceptual model of interactivity exhibits a 2x2x2 matrix. This diagram also shows how our concept sketches relate to the model.



Task

Museum visitors expect exhibits will be fun and challenging. For this reason, their behavior with interactive exhibits is goal-oriented. (At the lowest level, satisfying idle curiosity is still a goal.) Interactive exhibits challenge visitors with two kinds of tasks: quizzes and activities. In quizzes, the designer presents museum visitors with one or more goals and a set of procedures. Quizzes often involve "test your knowledge" tasks like answering questions, matching, sorting, etc. In activities, visitors set their own goals. An activity-based exhibit is like a child's set of building blocks. Building blocks offer natural constraints, which are inherent in their rectilinear form. A child can decide to build a house, a bridge or a pyramid, but she cannot, for example, build a keystone arch. In activities, visitors can determine goals beforehand, or they can integrate them with the task. A child can decide that she wants to build a pyramid, and then build it. Or a child can just start building and decide that the finished structure will be a tower.

Games fall into a grey area between quizzes and activities. Most simple games are effectively quizzes, with single goals and clear-cut rules. Complex, simulation games allow players to set complex goals, and fall closer to our idea of activities.

The important distinction for exhibit designers is that quizzes demand goal understanding while activities demand both goal understanding and goal setting — an extra cognitive step. As a general rule, if a topic does not lend itself to a concrete presentation, you should think about introducing it in a quiz format, allowing visitors to concentrate on principles rather than on goal setting.

Cognitive mode

In *Things that make us smart*, Donald Norman discusses two basic cognitive modes which are especially relevant to interactivity — experiential cognition and reflective cognition. "The experiential mode leads to a state where we perceive and react to events around us efficiently and effortlessly... The reflective mode is that of comparison and contrast, of thought, of decision making. This is the mode that leads us to new ideas, novel responses" (Norman 1993, 16).

Experiential cognition allows us to interact with the world on a perceptual level, without conscious deliberation. Riding a bicycle is essentially an experiential task. When riding a bicycle, I don't think, "pedal, pedal, lean — now turn." I simply do those things. Reflection involves conscious consideration. (We use that term from now on because we feel that reflection does not imply the action inherent in concentration.)

To add two numbers, I have to think: "Six plus seven equals thirteen. Write the three down here. Now carry the one."

The difference between experience and consideration is not clear cut. When I first learned to ride a bicycle, I did have to think, "pedal, pedal, lean, now turn." When I first learned touch typing, I had to consciously consider "Where is the 'E' key and which finger do I strike it with?" Riding and typing both didn't work out very well in the consideration mode. As I learned each task, I shifted into the experience mode. I seldom revert to consideration when I'm riding a bicycle, but with typing, I do so a lot.

While there is — from a user's perspective — a clear difference between experience and consideration, the relation is actually fairly complex. Experience relates primarily to physical or perceptual tasks, while consideration relates primarily to logical tasks. But if I'm learning a complex physical task I'll begin in the consideration mode, and I won't do it very well.

In interactive exhibits, we need to consider that experience and consideration relate to both the subject and method of interaction. Some subjects — like writing and coordinate systems — relate closely to consideration. Other subjects — planetary motion, for example — might best be explained experientially.

Motivation

In "What makes things fun to learn," Thomas Malone discusses two basic ways of motivating children to use educational, computer games. "A distinction is made between extrinsic fantasies that depend only weakly on the skill used in a game and intrinsic fantasies that are intimately related to the use of skill" (Malone, 1980, 10).

According to this view, the type of motivation is based on the relationship between task and reward. If there is a direct, cause and effect relation between task and reward, we can say the motivation is intrinsic. For example, if the reward for learning to drive is going places, then the motivation is intrinsic; there is a concrete relation between driving and going places. If the relationship between task and motivation is arbitrary, then motivation is extrinsic. Getting paid for learning to drive is an entirely extrinsic form of motivation. (Getting paid is extrinsic motivation to do anything. The paycheck as an abstract medium of reward is a recent, cultural development.)

Further examples of extrinsic and intrinsic motivation can be found in two popular educational games. In Trivial Pursuit, children learn facts about the world by moving around on a game board and answering questions about history, geography, literature and so forth. The first player who answers one question from each category correctly wins the game. Motivation in Trivial Pursuit is clearly extrinsic. Rolling dice and moving around on a game board has nothing to do with history, geography or literature.

In Monopoly, children learn about business practices by buying, selling and managing risk. The motivation behind Monopoly is clearly intrinsic, as there is a concrete relation between business practice and game tasks. (Even so, the game's goal of bankrupting the competition is a questionable business practice, even if it is highly motivating.)

Mihaly Csikszentmihalyi describes two similar concepts — "autotelic" and "exotelic" experience: "...when the experience is autotelic, the person is paying attention to the activity for its own sake; when it is not, the attention is focused on its consequences" (Csikszentmihalyi, 1980, 67). He gives the example of teaching children in order to make them good citizens (exotelic experience) and teaching children because one enjoys interacting with children (autotelic experience.) In a later article, he labels these concepts intrinsic and extrinsic motivation (Csikszentmihalyi and Hermanson, 1995).

The major difference between Csikszentmihalyi's autotelic and Malone's intrinsically motivating experiences is that in autotelic experience, the activity is its own, immediate reward; while with intrinsic motivation, the reward could come later as a direct, concrete consequence of the activity. To Malone, going places would be an intrinsic reward for learning to drive. To Csikszentmihalyi, the only truly intrinsic reward for learning to drive would be the joy of driving.

Interactive museum exhibits obviously need to provide autotelic experiences, whether or not motivation is intrinsic. Children view museums as "infotainment." A more difficult question is whether designers should base interactive exhibits on Malone's concept of intrinsic or extrinsic motivation. If a topic, molecular motion for example, lends itself to an intriguing demonstration, intrinsic motivation is a natural choice. Intrinsic motivation is also preferable for subjects in which the audience is highly interested.

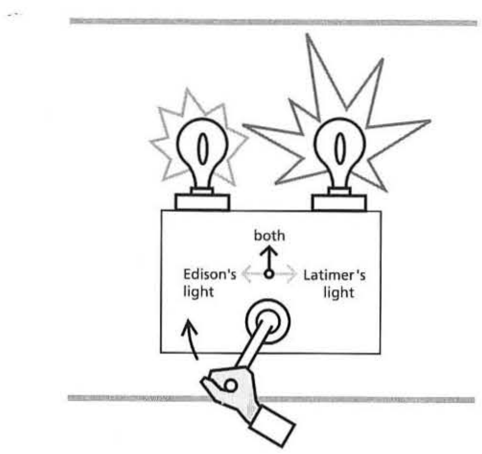
But where neither of these two cases apply, we feel extrinsic motivation becomes a viable alternative. A few years ago, one of us worked on an exhibit development team for Chicago's Museum of Science and Industry's "Star Walk" exhibition. The subject of the exhibition was children's mental health, and exhibits dealt with topics like appropriate goal setting, recognizing emotions and self-esteem (Whitney, 1988). Given these abstract and rather mundane topics, our exhibit prototypes made extensive use of extrinsic motivation. Doug

Cooper, teacher education manager of the Pacific Science Center, reports a similar experience: "We had an exhibit this year about problem-solving, and we know that if we advertised it as a problem-solving exhibit, it would not attract visitors" (Shields, 1992, 10). In the following section, we give a few illustrations of interactive exhibits that occupy different positions in our model.

Case studies: an illustration of the model

In order to show how task, cognitive mode and motivation apply to interactive museum exhibits, we've created concept sketches which illustrate some of the possibilities.

Figure 2

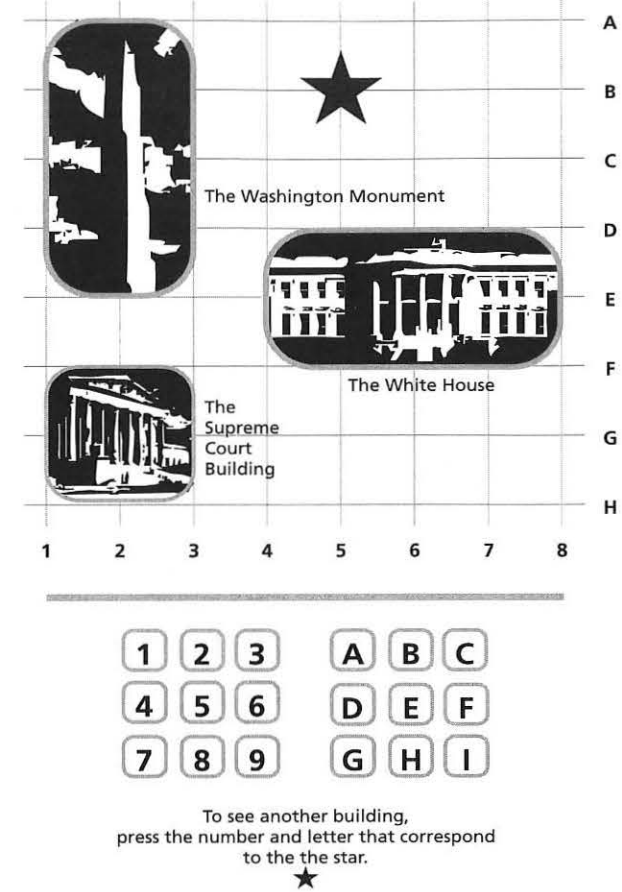


Louis Latimer's electric light

This concept sketch is intended as part of an exhibit about Louis Latimer, an African American electrical engineer and inventor who developed a vastly improved filament for the electric light. The sketch provides users with a hand dynamo and two light bulbs, one of which is perceptibly brighter than the other. A switch can direct electricity to either bulb or to both simultaneously.

One objective of this concept sketch is for children to notice which bulb is brighter. This is an experiential task which is extrinsic to electrical engineering, still, this kind of quiz can provoke curiosity and wonderment in children.

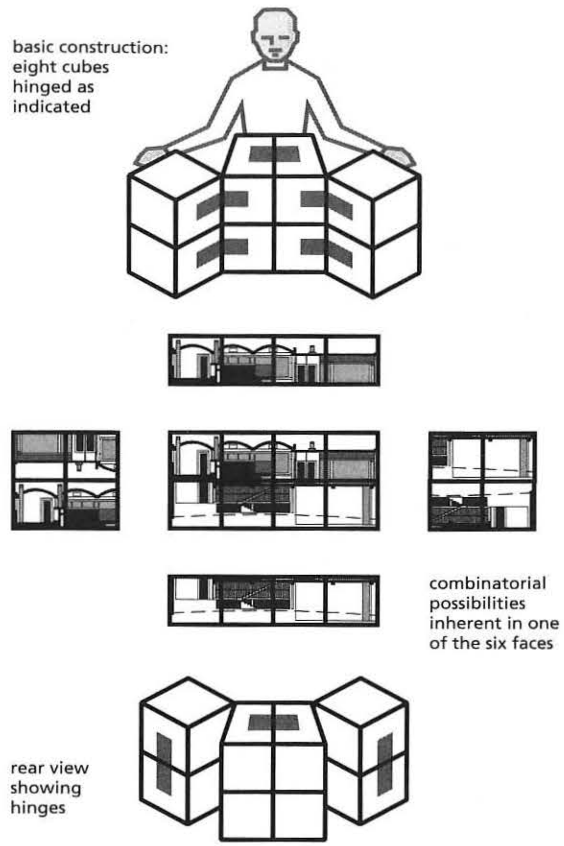
Figure 3



Famous buildings in Washington

This concept sketch is part of an exhibit describing the contributions of Benjamin Banneker, an African-American city planner, surveyor and author who was, among other things, responsible for the layout of Washington, D.C. One objective of this concept sketch is to teach children the basic concept of a coordinate system. As the exhibit allows only a single goal, it is clearly a quiz type activity-children make buildings appear by selecting their coordinates. Correlating coordinates with a two-dimensional plane is intrinsic to surveying, and the activity clearly involves conscious consideration.

Figure 4

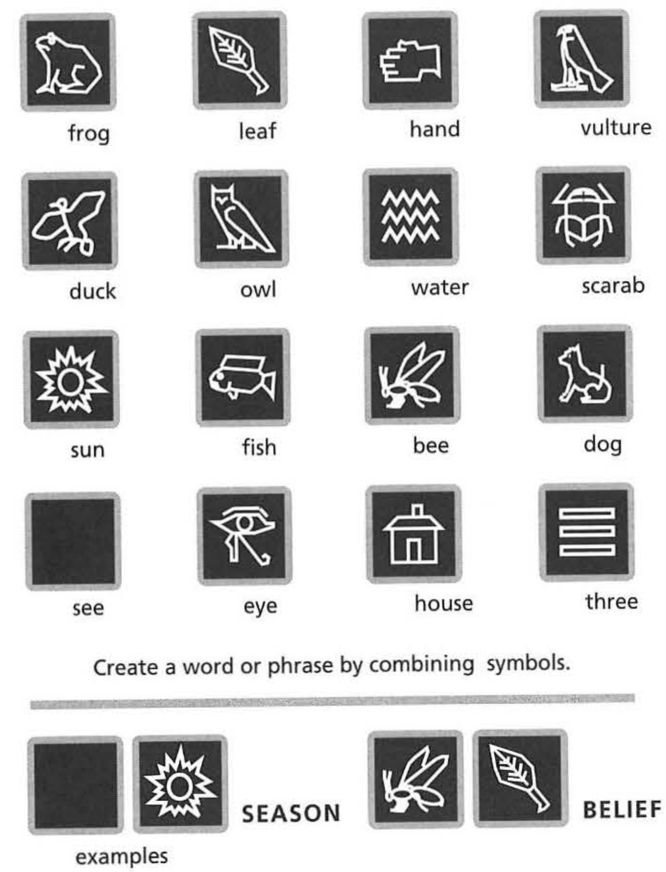


African-American Architects

In this concept sketch, children manipulate a three dimensional puzzle, where blocks are interconnected in a way reminiscent of Rubrik's Cube. The puzzle has four faces, each of which displays the work of an African-American architect. The puzzle allows children to rearrange the architect's work in a wide variety of combinations, demonstrating modular construction, mathematical patterns and constraints — all of which are intrinsic to architectural practice.

This concept sketch invites a child to become his own architect: there is no single, correct solution, but in manipulating the blocks a child experiences some forms as more pleasing than others. In this way, the puzzle provides an intrinsic, experiential activity.

Figure 5



Hieroglyphic building blocks

This concept sketch involves a set of hieroglyphic building blocks, loosely adapted from ancient Egyptian hieroglyphics. One objective is to teach children the concept behind syllabic writing. Children can combine these symbols into strings representing words or phrases. In this activity, children can express a multiplicity of meanings, requiring conscious consideration. Combining symbols is intrinsic to written language.

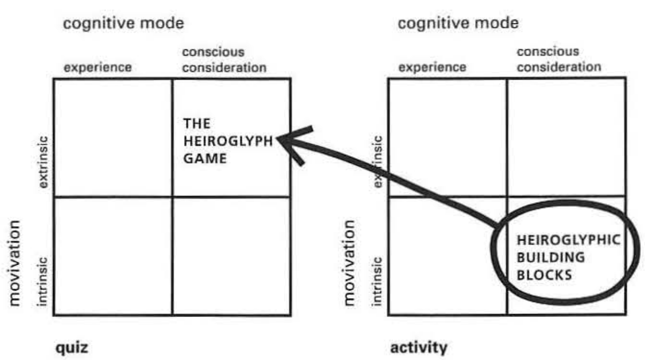


Figure 6

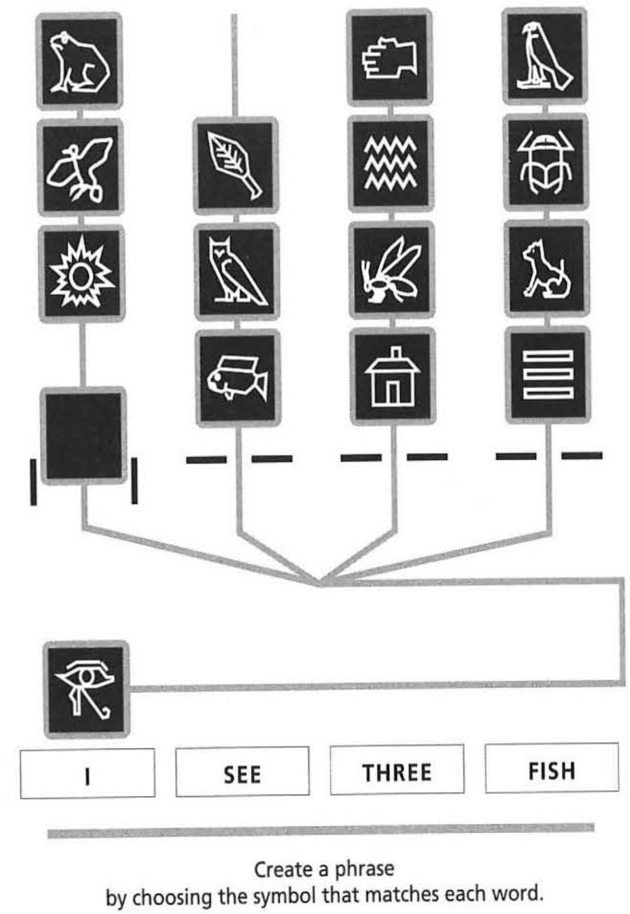
Transposing a concept to another place in the model can suggest design possibilities.

The model as a generative tool

Our model of interactive exhibits provides designers with a way of rethinking basically sound concepts that don't quite work. Our model allows designers to pose questions like: What if my concept were an activity instead of a quiz? Or: what if it involved experience instead of conscious consideration?

In order to show how this process might work, we have created a variant of the "Hieroglyphic building blocks" exhibit, which presents a different approach to the same concept. "The hieroglyph game" is a pinball-like game, where hieroglyphics pass through gates and slide down a path. Pinball is extrinsic to written language, and this task is a quiz because the children try to match a given phrase. While there may be ways to make the exhibit experiential, we kept to conscious consideration as that mode fits naturally with language.

Figure 7



The Hieroglyph Game

Will "Hieroglyph building blocks" or "The hieroglyph game" work better as an exhibit? We won't know without evaluative testing. Our model is generative, not predictive, and we recommend a development process like the ones used by Jarret (1986) or Diamond (1992). But if a visitor finds himself at loose ends with an activity, try a game or quiz.

Exhibit design and affordances

Our conceptual model for interactive exhibit design defies common wisdom in that it treats each component of our key considerations — quiz/activity, experience/conscious consideration, intrinsic/extrinsic motivation — as equally viable alternatives. Exhibits in the Exploratorium are primarily intrinsically motivated, experiential activities. In his "Exploratorium exhibit conception and design," Frank Oppenheimer (1980) reports that Exploratorium exhibit designers routinely ignore "who your audience will be," and that many single activity exhibitions (or quizzes, in our terminology) have proved "extremely disappointing."

We argue that Exploratorium exhibits are unique in that they demonstrate physical phenomena — an area that allows designers to incorporate "perceptual affordances" into their exhibits. Perceptual affordance is a term first used by the psychologist James J. Gibson (1982). He believed that experience — not memory — lay at the root of much of perception and viewed perception as the ability to operate in an environment. The "total experience" he wrote about is entirely consistent with Exploratorium exhibits — requiring movement through an environment, touch, sound and balance as well as sight, and the opportunity to experiment.

Gibson believed that light enters the eye in an inherently meaningful code, reflecting categories which naturally exist in the environment. Perceptual affordances are one such category: objects that invite interactivity. According to Gibson, stairs afford climbing, a chair affords sitting, a level surface, such as a table top, affords laying an object on top of it. Rather than relying on memory, our perceptual system tunes in to affordances just as a television tunes into a channel.

Affordances explain why Exploratorium designers don't have to worry about their audience — their exhibits take advantage of low level perceptual processes common to all people. And because the interaction is experiential, museum visitors can consciously consider goal setting. (This may explain why quiz exhibits seem disappointing in comparison.) One limitation is that affordances can only demonstrate concepts that are tangible — and may fit science exhibits better than exhibits on language, history or social relations.

But even in exhibits which use extrinsic motivation and require conscious consideration. The concept of affordances should play an important role — museum visitors should not have to consciously consider how to operate an exhibit. We've observed a number of exhibits that visitors cannot figure out how to operate. They try several things which fail to work and leave frustrated. Sometimes they tell others that the exhibit is broken. The usual museum response is to attach a label containing printed directions. Later visitors commonly ignore these and experience the same frustration.

Poorly designed interactive exhibits are like digital watches. There seems to be no easy, natural way to set a digital timepiece. The difficulty is certainly operational, not conceptual, we know what time is. Instructions may help, but they are a poor solution. If we look at an old-fashioned analog watch, we have no such problems. The stem affords turning, and it's simple logic that the hands turn in harmony.

A decade after Gibson's death, his theories remain controversial. But designers feel they are a useful way of looking at people's interactions with objects (Smets, 1989; Gaver, 1991). While user interface is not a central part of our work, we advocate taking advantage of affordances wherever possible and basing exhibits on structures which afford manipulation — cranks which afford turning, buttons which afford pushing, levers that affording pulling, etc.

Should designers be biased toward intrinsic motivation?

Thomas Malone strongly favors intrinsic over extrinsic motivation. "If students are intrinsically motivated to learn something, they are likely to spend more time and effort learning, feel better about what they learn and be more likely to use it in the future" (Malone 1980, 10).

In this study, we take a different position. As previously mentioned, attraction is a critical factor in exhibits — and visitors may not find all subjects intrinsically motivating. Also, numerous varieties of both forms of motivation can be found in the real world — not only in things like popular games, but in real world practices, like jobs, which have developed through centuries of cultural practice. We view intrinsic and extrinsic motivation as elements that exhibit designers should apply consciously to best advantage.

We would, however, add a cautionary note for designers who choose extrinsic motivation. Screvin (1986, 114) states that some efforts to motivate viewers prove counterproductive, noting that three-dimensionality, novelty, gadgetry and manipulatory aspects can distract visitors from the main ideas, distinctions or story line of an exhibit. Extrinsically motivating activities need to be used in an applied way that promotes visitor attention to the subject matter.

Our approach to African-American children

African-American children should not just learn about their history and cultural practices — they need to gain an affinity for these things. They should gain a sense that careers which have historically been closed to them are within their abilities and reach.

In illustrating our model of interactivity, we've kept things straightforward and have chosen subjects which involve logic, science, linguistics and architecture, using African-American pioneers in these areas as points of departure for basic principles in their subject area. One reason we took this approach is that the contributions of African-Americans have generally been ignored by the museum community (Corrin, 1992). While we believe that social issues can be subjects for interactive exhibits, we have left this as a topic for further research.

Conclusion: the model as a design tool

An essential part of the exhibit design process is visualizing different forms that a basic concept might take. The model for interactive exhibits described in this paper might help with this process. Our model does not work like a recipe book, it's more like a map when you're out for a Sunday drive, it tells you where you can go, but leaves it for you to decide when you've found a neat place.

The model allows you to ask questions such as: What form could my concept take if the motivation were intrinsic? Could I add extrinsic rewards as well? Would the challenge in my concept be more appropriate as a quiz or activity? Is the subject and activity behind my concept expressed best through an experiencial mode or by conscious consideration?

Obviously, the world of interactives is not as simple as three sets of polar opposites. There are grey areas between all three dimensions of the model. At the same time, the components of the model are invariably combined within real exhibits. Good exhibits do not happen by accident. We advocate a simple, memorable model as a way of recognizing the design possibilities inherent in interactive exhibits. We present concept sketches as examples because we believe our model of interactive exhibits may be most useful in the early stages of exhibit development. We realize our sketches must undergo many refinements involving design for interaction, learning and fabrication before they will function in a museum environment.

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