Interactive Exhibit Design Issues

While interactive exhibit design is certainly not an exact science, there are some guidelines that can help ensure an effective design. Maton-Howarth (1990) identifies four critical elements in the production of any learning system or educational exhibit:

1.) *motivation*: the need to stimulate initial interest;

2.) *meaning*: the need to pose a problem to be solved, thus creating structure, relevance and context;

3.) *interaction*: the need to provide a variety of activities to the solution of the problem, while generating the discovery of other information; and

4.) *reinforcement*: the need to further interest and the desire for continued learning in and out of school (p. 194).

The need for motivation is clear in its importance and has always been a constant challenge for educators. Attracting the learner's attention and motivating them can be done in a number of ways, but as Maton-Horwath (1990) states, it is particularly successful when calling upon multiple senses to convey the information. Instead of using only written narratives to stimulate interest for example, visual and auditory means can be incorporated. The second factor, providing meaning by creating a problem to solve, can create a great degree of satisfaction and motivation to participate. This is particularly true when the motivation is intrinsic and the issue at hand can be related to past experience or information. Interaction, the third element, provides the substance of the learning experience. It is through interaction with our environment and other individuals that we all develop our most essential knowledge, e.g., children learn to speak and survive through interaction with their environment. The final element of reinforcement actually occurs as part of the natural cycle of building on previous learning through voluntary interaction, adapting to new information, and resulting in increasingly complex behaviors. Once these elements are accounted for, specific objectives and particular circumstances can be integrated into the system.

Most of these same elements were referred to by the interview participants as key success factors for interactive exhibit design, specifically factors related to motivation, meaning and interaction. The most frequently mentioned responses pointed out the importance of *engaging the visitor*, providing *multiple stimuli* for alternative learning styles, frequent and meaningful interaction, and an *environmental* approach to exhibit design that compliments the content and surrounding exhibits (see Table 6). The need for reinforcement of ideas, Maton-Howarth's fourth element, was not indicated as an exhibit success factor although a few participants mentioned reinforcement as an important element of a good exhibit during other parts of the interview. Probably related to their longer experience with interactive media, the science museums identified the greatest number of interactive design issues, but there was still substantial agreement across all categories of museums on a number of items aside from those just mentioned - attractive and simple design with an intuitive interface, and understanding the visitors' needs to name a few. Appropriate use of the technology's capabilities was also an important factor, remembered by those who had seen poor exhibit design based on the "wow" of technology as opposed to content objectives.

Table 6
What Are the Key Success Factors for Interactive Exhibits?

	Totals by museum type					
Key success factors for interactive exhibits	art	hist	chld	sci	oth	ttl
Total engagement through multi-sensory interaction		1	2	3		6
Meaningful/creative interaction that builds connection	1	3	1	1		6
Physical environment should complement exhibit	1		2	3		6
Frequent Interaction				3	1	4
Appropriate use of the technology/capabilities			1	2	1	4
Multi-dimensional (aesthetic, kinesthetic, educational)	1		3			4
Attractive/exciting front end				2	2	4
Make it look simple (content & interface)	1		2	1		4
Understanding visitor needs	1	1	1	1		4
High quality graphics				3		3
Personalization - visitor can have unique affect			1	2		3
Color - bright or merely the use of	1	1		1		3
Designed so small groups can use		1		2		3
Do formative evaluation & testing			1	2		3
Never let user get lost/good navigation clues	1			1	1	3
Having an active role - control	2			1		3
Front end analysis of audience		1		1		2
Immediate feedback				1	1	2
Has to be fun		1		1		2
Variety of interaction types, also changing over time		1	1			2
Show relevance of topic to individual			2			2
Clearly defined objectives		1		1		2
Automatic reset to attract loop	1			1		2
Involve body movement whenever possible		1		1		2
Encourage cooperative learning			1			1
Percent of responses by category	**13%**	**15%**	**23%**	**43%**	**8%**	80

A specific example of engaging multisensory presentation is the multimedia exhibit in the St. Louis Zoo's *Living World* gallery, which lets visitors learn about the characteristics and songs of various birds, selectively viewing images, descriptive text, and sounds. An example of creative interaction, which has consequently led to unintended learning outcomes, was described by the Boston Computer Museum. In their series of computer-based exhibits on health, visitors can learn about their physical characteristics, condition, etc. One exhibit uses an infrared beam to measure the visitor's height as they step in front of the computer. A related exhibit uses motion sensors to track the visitor's location in relation to the exhibit, and responds to the visitor based on this input. In both exhibits, visitors have been able to learn about their physical attributes and explore the health topics of interest in those exhibits, just as the exhibit designers intended, but in addition some visitors were observed trying to fool the system once they had learned how the motion detectors or infrared lights worked. The designers may not have intended to teach about those mechanisms, but the visitors learned about how they work because their interest was piqued. Both examples highlight the attraction to discovery-based learning environments, which encourage visitors to ask questions, explore, and learn on their own.

The associations and experts who were interviewed most commonly pointed out the importance of *ease of use/simple interface* and *interesting content,* both of which were mentioned by museum participants as well (see Appendix C for association and expert summaries). Easy to use interfaces actually refers to two design elements. One is the hardware interface, such as the touch screen on the computer monitor, and the other is the interface metaphor used, which refers to the navigation system incorporated into the screen design. The metaphor is specifically important because it indicates to the visitor how to use the system and therefore is an integral part of the communication process and navigation system. Real world metaphors (i.e., a desktop) are often used to illustrate the information to be found in a computer environment (i.e., files or documents) because they can provide a frame of reference for the visitor to use to infer the activities that are possible in that environment (Laurel, 1990). In museum exhibits, the icons (i.e., the graphical elements that allow the user to move about the program) need to be intuitive to a very broad audience.

Independent exhibit designers tended to described the important factors from the designer's perspective, such as the importance of *clearly defined goals* and *presenting information quickly* and in *small chunks* (see Appendix C for independent exhibit designer summaries). Several designers mentioned the need to limit the vertical complexity (the depth of information provided on any one topic) and the horizontal complexity (the breadth of topics covered) of the information included in museum exhibits. If there are too many paths for the user to take (an example of horizontal complexity) the choice of where to go becomes random. If there are too many layers of information on any one topic (an example of vertical complexity) the visitor can get lost or annoyed. The trick is to keep the design simple, yet have enough information to satisfy the members of the target audience - another challenging design problem that is dependent upon understanding the visitors personal, physical and social contexts. Independent exhibit designers also mentioned the importance of an *aesthetically appealing design* and *frequent interaction,* both elements which were referred to by the other participants.

When asked to rate a list of exhibit variables (scale of 1 to 5, 1 being extremely important, 5 not at all important) in terms of their importance to the success of an interactive technology-based exhibit, museum interviewees indicated that the *extent of visitor control* was the most important factor of those listed, with an average rating by all of the museums interviewed of 1.6 (see Table 7). Visitor control refers to the degree of freedom to move about the program, with higher control allowing the visitor to easily explore and get to the information in which they are specifically interested. However, a few of the participants who rated this factor lower than the average (from 2.0 to 3.5) stated that the importance of visitor control depends on the exhibit objectives and on the inherent attractiveness of the content and the display. One participant stated that *some people don't want control (older adults) and some exhibits that are really engaging don't need to have visitor control to be good.*

Table 7

How Would You Rate the Following Elements in Terms of its Importance to the Success of a Technology-Based Exhibit?

Average rating of factors' importance to success of exhibit.

(1 = very important, 3 = somewhat important, 5 = not at all important)

	Art	Hist	Chld	Sci	Oth	W/avg*
Extent visitor control	1.7	1.9	1.8	1.3	1.5	1.6
Extent topic made relevant	1.5	1.3	1.6	2	3	1.8
Exhibit environment	1.7	2.9	1.6	2.5	2.5	2.3
Range audience attracted	2.7	2	2	2.8	3	2.5
Depth of information	1.7	2.5	2.5	2.8	3.3	2.5
Percent audience attracted	3.3	3.1	1.4	2.8	2.5	2.6
Location in museum	2	3	1.9	3.3	2.5	2.6
Average	2.1	2.4	1.8	2.5	2.6	

* Weighted Average based on 19 responses.

Success Elements: Extent of visitor control - refers to the level of user manipulability of the exhibit; the level of freedom and interaction opportunities. Extent topic made relevant - refers to the extent that the topic of the exhibit is made relevant to the visitor's existence or daily life; presentation of some commonality that would make the exhibit of interest to the visitor. Exhibit environment - refers to the exhibit setting characteristics and how important the areas surrounding the exhibit are to that exhibit's success. Range of audience attracted - refers to the breadth of visitors who interact with the exhibit, a high range being young and old, of various ethnicities, education levels, and so on. Depth of information - refers to the depth of information that is contained in the exhibit; the extent that visitors would have all/most of their questions about the topic answered through the exhibit. Percent of audience attracted - refers to the percent of visitors who interact with the exhibit. Location in museum - refers to the importance of the exhibit's location within the museum setting; whether there are advantages/disadvantages to certain locations (i.e., near the entrance).

The second highest average rating (1.8) was given to the extent that the topic (through its presentation) is *made relevant to the visitor.* This refers to the extent that the visitor can discern how the content being presented is related to, or important to him or her as an individual. An example would be showing how littering on the street can create pollution and affect the visitor's drinking water. Relevance generated high ratings by the participants who felt that making the topic relevant to the visitor is what creates interest in the exhibit. Lower ratings were given by participants who agreed that the relevance, or the ability of the visitor to see him/herself in relation to the exhibit topic is important, but they qualified their response by stating that not every topic can be made meaningful to every visitor. They also felt that an exhibit can be "successful" even if it is only relevant to a small group. Clearly each of the participants felt this to be an important factor.

The third highest average (2.3) rated element was the importance of the *exhibit environment.* This can refer to a number of variables including the presence of seating, the creation of surroundings that are aesthetically consistent with the rest of the museum, attention to the context of the exhibit and how it relates to its content, and how the visitor is drawn into the exhibit space. Higher ratings for this element were given by participants who felt that it is very important to think about how the exhibit fits into the complete museum experience and how space is used to draw the visitor in to that particular exhibit. Lower ratings were given by some who were uncertain as to how important issues like seating, noise, etc., are to an exhibit's success. Art museum responses showed the most controversy in this area. Some art museum participants felt strongly that computer exhibits do not belong in the exhibition gallery but in completely separate educational rooms. Others felt that situating the art near the computerized information was a very effective method of heightening awareness of the art. One association participant commented that these types of disagreements have prevented interactive technology from being implemented in art museums on more that one occasion.

Examining the rankings by museum category shows how the importance of the elements varied by museum type (see Exhibit 3). Children's museums gave the highest ratings overall, with a 1.8 average. This resulted from having the highest average ratings by museum type for four out of the seven elements. The *percent of the audience attracted* (1.4) and *extent the topic is made relevant* (1.6) to the visitor were the two most important factors to this group. One children's museum noted that it is impossible to attract everyone, but that at least 70% to 80% of the exhibits should be attractive to everyone on the target audience. Because of the greater homogeneity of the children's museum audience, expecting an exhibit to attract a greater percentage of the audience is a more realistic goal than for the other museum categories. And in fact, the participants from other museum types who gave this factor lower ratings commented that they did so because they tend to have a diverse audience whom are rarely all interested in or attracted to the same types of exhibits. They added that an exhibit can work well for some visitors and not for others and still be a very important and successful exhibit. The lowest rating given by the children's museums participants was a 2.5 for the depth of information provided; understandable given the motives and generally lower attention span of their audience.

Art museums gave the second highest overall average rating across museum types at 2.1. *The extent the topic is made relevant* was this groups highest rated element (1.5), again because relevance makes the topic interesting to the visitor, followed by *depth of information, extent of visitor control,* and *exhibit environment* rated equally important (1.7). Several art museums supported their high rating for the depth of information as an important success factor by commenting that the potential of interactive technologies is to provide as much information as a person could want: *This doesn't mean that they have to access it, but it's there if they want to. The design problem is then to hide the depth if they don't want to know more.* This philosophy revels itself in the number of art museum videodiscs that have been created to provide some of the depth of an art history background to the novice, and also in the digital image databases that serve as a reference to the museum's entire collection, most of which is often inaccessible to the general public. A specific art videodisc example is the J. Paul Getty Museum's videodisc titled *Greek Vases,* which is based on the museum's collection (Information Technology, 1987, p.67). *Greek Vases* allows the visitor to selectively explore four main paths of information: subject matter, potting and painting, form and function, and artistic quality, and each section has a number of branching opportunities (e.g., from subject matter one can branch to gods, heroes, creatures, or mortals). Reasons why this implementation is considered to be so successful are the program's easy to understand icons (i.e., good graphic design), high image quality, and the clear fact that a lot of thought was put into the topics and content (Information Technology, 1987, p.67; Interview: Behind the Scenes Publishing, 1992; Telephone conversation: J. Paul Getty Museum). Some of the science and technology museums rated the depth of information as only somewhat important (3.0 - 3.5), because they felt more information was often not necessary (i.e., not demanded by their audiences) and potentially confusing to the user. Children's museums rated this factor even lower (3.0 - 4.0), because they did not see it as their function to sustain long periods of interaction. It is more important to science and children's museums to attract and engage the visitor, and to create an introductory perception of the idea being presented.

History, science and other museums rated these seven elements the lowest of all the museum types, on average (2.4, 2.5 and 2.6 respectively). On the other hand, science museums rated the *extent of visitor control*, which was the element that ranked highest on average for all museums, the highest among the museum categories (1.3). This concurs with the hands-on experiential learning approach so strongly advocated in most science and technology centers. Science museums rated the *extent that the topic is made relevant* second in importance, on average (2.0), for reasons already stated, and the exhibit location within the museum the lowest in importance (3.3). While no specific science museum comments were recorded for this question, two history museums which gave this element lower ratings (3.0 and 4.0) said that the importance of the location can be significant, but that it depends on the exhibit and sometimes can't be controlled. Two children's museums on the other hand, stated that the location can have a significant impact on the success of an exhibit, both in terms of the frequency of its use and in terms of keeping the visitor within a learning context derived from the surrounding exhibits.

Although history museums also gave a fairly low overall average rating (2.4), they showed an exception for the *extent of relevance* to the visitor, which history museums ranked the highest (1.3) compared to other museum ratings for this category. The *extent of visitor control* was rated second highest of these elements (1.9) by the history museum participants. History museums also gave the highest rating along with children's museums for the *range of audience attracted*, both at 2.0. One history museum which rated this factor fairly important (2.0) commented that while the breadth of the audience that is attracted to an exhibit is important, the interactive computer-based exhibits don't appeal to all segments of the target audience. Some of the lower ratings (3.5 - 4.0) given to the range attracted by other types of museums were based on feelings that the diversity within the target audience that is attracted to a thematic area is very important, but that the range attracted to any one exhibit within that exhibition (i.e., the thematic group of exhibits) is not very important. Most of these participants consider the visitor's response to the museum as a whole to be the more important issue, although certainly each exhibit needs to be evaluated on its own merits.

Exhibit 3

Factor's Importance to the Success of an Interactive Technology-based Exhibit

Museum Type	Most Important	2nd Most Important	Least Important
Art	Topic's relevance	Depth, Visitor control, & Environment (tied)	% Audience attracted
History	Topic's relevance	Visitor control	% Audience attracted
Children's	% Audience attracted	Topic's relevance	Depth of information
Science	Visitor control	Topic's relevance	Exhibit location
Other	Visitor control	% Audience, Location, Environment (tied)	Depth of information
Across Museum Average	Visitor Control	Topic's Relevance	% Audience attracted & Location of exhibit

Note: See Note to Table 7 for a definition of the factors abbreviated in this table.

There are certainly numerous ways to attempt to engage the visitor in an exhibit and impart new knowledge. Once the objectives of the exhibit and the content have been clearly established, the next basic steps in the design process are to select the media (the vehicle(s) of communication), and the mode (the way(s) the media are used) (Miles et al., 1982). Examples of media include artifacts, labels, videos, pamphlets, computers, and numerous hands-on devices such as microscopes or pendulums, to name a few. There are also a variety of modes, including static displays of artifacts, dynamic or interactive exhibits which can include games, simulations, role playing, searches, problem solving, activities and experiments, and tactile and auditory experiences (Booth et al., 1982; Miles et al., 1982). The information delivery method (including media and mode) is critical to educational exhibits because the ability to transfer information is considered to be the key to significant learning (Gagn), 1977). This transference, in turn, is tied to how people process and remember information.

Information is stored in an organized manner; it is not just collected as disparate facts, but is processed by encoding it into meaningful units, spatial arrangements, or images (p. 55). To aid in encoding and remembering, the use of a story line or other strong, simple context is often recommended for educational exhibits (Miles et al., 1982). One exhibit designer for the Austin Children's Museum describes the importance of context to the learning experience by stating that learning often takes place after the child has left the museum. It is when they see something at home or elsewhere that reminds them of what they have, perhaps subconsciously, learned at the museum that the "aha" of learning often occurs (personal communication, 1992). Communication is successful when the visitor's attention and interest in the subject matter is high enough for the information in the museum to be transferred to another environment.

Many of the museum participants commented that the process of defining a media and mode strategy should develop naturally from the message to be told, as determined by the exhibit objective(s) and related factors (e.g., the target audience). For example, if the objective of the message is to teach about fossil formation, an appropriate delivery of that message might be to display a fossil, perhaps within the context of the rocks that had formed it, and a label to describe how it was formed. Similarly, a sand box press can be displayed or offered for individual hands-on manipulation and a more direct experience with the information being presented. A third alternative might be a computer-based exhibit using animation to show a more engaging presentation of fossil formation, but this would clearly require specific design skills and greater financial resources. A video of a historian describing fossils, on the other hand, would not be a logical approach, and it is fairly clear why it would not be - there is no context, it is hard to grasp the content without seeing it, and the visitor could get practically the same experience by reading a book. Unfortunately, the choices of what media or mode to use do not always seem so clear to communicators. Media selection in particular becomes difficult when one has to consider the ever-growing plethora of new interactive technologies available for use in multimedia exhibits.

Multimedia Hardware

Today there are several combinations of technologies that can be described as multimedia technology. The newest and most popularized version of multimedia in the technological sense is described as a system which integrates text, audio, graphics, animation, and video into a single computer-controlled program (McCarthy, 1989; Todd, 1992). Virtual reality systems are also multimedia technologies, in that they use computer simulations and specialized "wearable" hardware to place the user inside the virtual, multisensory environment. There are also many other derivations that offer the essential multimedia components but lack the computer as the user's controlling platform. Basic videodisc systems are an example, since they are operated by remote control or buttons and have no computer interface (McCarthy, 1989). The multimedia systems which use a personal computer as an integration device for all the media are currently the most popular high-tech tools because they afford the designer through programming, and the end-user through branching and browsing, the greatest control over the information in the program (McCarthy, 1989). Introductions of new technologies offering users and designers more capabilities and greater control will undoubtedly continue to upgrade what is considered to be high-tech or popular. But for now, the basic hardware needed for a multimedia system includes the computer platform, input and output devices, and storage media.

Platforms. The current major multimedia computer platforms are IBM DOS/DOS compatibles, Apple Macintosh (Mac), Commodore Amiga, NeXT, and Silicon Graphic's IRIS Indigo (Burger, 1993). Tandy, Packard Bell, and NEC are among the many other companies who have introduced multimedia systems as well. Although each platform has varying capabilities, each can be combined with its operating system and other necessary software to allow the multimedia designer to create and develop multimedia presentations and other products for delivery on the same platform. There are numerous additional computer hardware peripherals needed to complete a multimedia computer set-up, such as special computer boards which digitize audio and video so that the signals from those media are compatible with the computer's electronic signal (Martin, 1992; Pogue, 1992; Revaux, 1992b).

When the museum interview participants were asked what computer platforms they currently had in place, most reported Macintosh (see Table 8). Reasons for preferring Macintosh over other brands were that Macs are more amenable to visual presentations and have more development tools and software. Five participants stated that they use a mix of platforms, primarily Mac and DOS based, but some also included DEC and Amiga. Only two museums reported using IBM/DOS compatible computers exclusively. In contrast, of the independent exhibit designers interviewed, three worked primarily on DOS/PC clones, and three primarily MAC (see Appendix C for a complete list of the Independent Exhibit Designer responses). While many noted the Mac's superior interface and development tools, DOS machines were sometimes said to be more attractive because of the lower cost and open architecture, and because more independent designers have custom programming skills which circumvent the attraction of or need for the Mac's off-the-shelf programming tools.

Table 8
What Computer Platform Do You Use?

	Totals by museum type					
What computer platform do you use	art	hist	chld	sci	oth	ttl
All Macs	2		3	1		6
Majority of MAC/tend to use/prefer MAC	1	1	1	2		5
Use a mix of platforms (Mac, DEC, DOS, Amiga, etc.)			1	2		3
Have a mix of Mac & DOS				2	1	3
Only DOS/compatibles		1		1		2
DEC		1				1
Don't know	1					1
n/a	1	1				2
Percent of responses by category	**21%**	**21%**	**21%**	**29%**	**8%**	24

Input/Output. The input output devices (I/O's) include a number of technologies all geared to allow people to put information into the computer, or get information out. Some of the most common input devices include: keyboards, mice, joy sticks, track balls (the last two commonly used in video and arcade games), graphic tablets (which allows users to use a pen-like object to record drawings in the computer), touch screens, scanners (which import digitized photographs of printed materials into the computer for manipulation and/or storage), cameras and microphones. Common output devices include printers, monitors (the computer screen), and video recorders, projection systems, and stereo systems. Very few of these are standard components of any computer system, with most requiring supplemental purchases. In addition, there are several devices that function as both input and output devices, namely modems (which allow two-way communication via phone lines) and musical instrument digital interface (MIDI) devices which allow importing or exporting of synthesized sounds (Burger, 1983).

A rather unique set of input/output devices have been created by the virtual reality field. Virtual reality is actually both a state of mind and a set of technologies. As a state of mind, VR represents any simulated environment in which an individual feels immersed and separated from actual (i.e., physical) reality. The technologies of VR work together to create computer-generated (hence "virtual") 3-D environments in which users interact with information or objects via special input and output devices (Koester, 1992). Besides a powerful computer and simulation software, the input/output hardware required for the simulation of VR can vary from system to system, with the classic configuration including a "dataglove," which the user wears on a hand to send and receive data from the computer, and "goggles" which update the computer simulation directly in front of the users eyes. As such, VR represents a new generation of input/output devices and user-interfaces, and it offers a completely unique interaction from any of the other hardware systems mentioned (Newquist, 1992, p. 93).

In terms of exhibits, the most important part of the I/O formula is the "I," stand for interface as well as input. Both interfaces issues are important considerations for the museum environment. Since visitors are in search of social and entertaining experiences, they are unlikely to spend a significant amount of time learning how to "work" an exhibit. As such, interfaces can represent either an open door or a barrier to the entertaining or educational encounter. Careful design of the interface must make the interaction as natural and intuitive as possible, or the exhibit will go unused. A mouse interface, therefore, which would require knowledge of how to "click" and "drag," might not be appropriate for the diverse skills and backgrounds of museum audiences.

With this in mind, participants were asked whether they had discovered anything about the effectiveness of various hardware interfaces, and most responded that touch screens were the best interface for interactive systems because they are intuitively easy to use and have a clean design (see Table 9). Among museum types, art museums prefer touch screens, while children's and science museums also like using trackballs when they want a more economic, playful, and physical solution. Science museums are the most likely to have tried a wide variety of interface types, which is logical given their greater experience with technology.

Participants discovered that kids are more likely to approach and touch a screen than adults, and attribute this to the affects of the techno-age on children. Although maintenance of touch screens (both in terms of periodically needed calibration and daily cleaning) is an issue for many museums, several mentioned they have noticed improvements in reliability and quality of the newer touch screens. There were also a few negative comments regarding this interface: the design leads the user to block the screen when they are interacting, and some participants feel that touch screens actually detract from the significance of the interaction. A technology museum designer believed that you could never have too many design choices at once (i.e., in one exhibition area), and other participants mentioned that they have seen a number of interfaces work equally well in different exhibits. No one reported any research on the use of different interfaces for duplicate exhibits, which would be a more meaningful way to make comparisons about the effectiveness or attractiveness of the various interfaces.

Table 9

Have You Discovered Anything About the Effectiveness of User Interfaces?

	Totals by museum type					
Effectiveness of user interfaces	art	hist	chld	sci	oth	ttl
Use touch screens	3	3	3	2	2	13
Like/use track balls	1	1	3	4		9
Have used a variety of interfaces				4		4
Interface depends on the objectives of the exhibit			2	1	1	4
Use buttons	1	1	1			3
Use joysticks			1	1		2
Use mice		1		1		2
Use control/"black" box				1		1
Use keypads			1			1
n/a	2	1	1			4
Reasons/Comments						
Buttons are usually meaningless/ineffective			1			1
All interfaces can work well if presented well				1		1
Many people haven't experienced track balls or mice				1		1
Track balls are cheaper & low/no maintenance		1		1		2
Touch screens provide easy/intuitive/clean interaction	2	1	2	3	1	9
Maintenance has been /can be an issue with touch screens	2		1	1		4
Touch screen works better with kids than adults				2		2
Maintenance has not been an issue with touch screens		1			1	2
Do not like touch screens				1		1
Layers of information are less clear with touch screens		1				1
Touch screens are prone to breaking down				1		1
Touch screens are much more expensive				1		1
Had problems with people stealing mice, so discontinued		1				1
Touch screens are very reliable these days				1		1
Percent of responses by category	**15%**	**17%**	**23%**	**38%**	**7%**	71

Norman (cited in Laurel, 1990) states that the most common problem with computer interface design is that it is done as if it were just a pretty patch up job, *after* the product has been designed. "We ought to be asking what tasks people need to accomplish, what tools are most appropriate for those tasks. We need to ask those questions with the entire working environment in mind, with an eye toward the effect our tools will have on that environment" (cited in Laurel, 1990, p. 7). While museum exhibit designers are probably not going to start designing alternative computer interfaces right away, (though there is no reason to discourage them) it is important to recognize that the interface should help meet *user* objectives, and that formative testing of exhibits can uncover many interface design problems previously not imagined.

Storage Media. Storage media are the technologies which hold the digital or analog data until the computer user needs to access, manipulate, or modify the information. Storage media can be internal or external to the computer (if external, they require separate hardware to access the information they contain), and they can be divided into two general categories of technology: magnetic and optical media. The standard storage and recording media for the computer industry has historically been the magnetic media of floppy disks, tapes, and hard disk drives (Burger, 1993). However, due to the enormous memory (same as storage) requirements for the audio, video and graphics used in multimedia productions, new media based on optical technology have been developed. Optical technologies have gained popularity due to their much greater storage capacities, improved durability, low duplication cost, and data safety, as well as for the capacity for random access which is possible with certain digital media (Burger, 1993, p. 472). Optical media can also be further broken down into three general categories: compact discs (digital), videodiscs (digital audio, analog video), and writeable optical media (digital).

Compact Discs. The success of the 5-inch consumer audio compact disc was the driving force behind the development of numerous other compact disc technologies (Weiman, 1992). Compact disc technologies are read-only formats, which means the information on the disk can be accessed but not changed. These include audio compact disc (CD's, or CD-DA [digital audio]), compact disc-read only memory (CD-ROM), CD-ROM XA (CD-ROM Extended Architecture), CD + Graphics, Compact Disc-Interactive (CD-I, by Philips, NV, the Netherlands), CDTV (Commodore Dynamic Total Vision), and Kodak Photo CD (Burger, 1993; Helsel, 1990; Pring, 1992; Weiman, 1992). Each compact disc technology is essentially a variation on the same theme: a storage medium for large amounts of text, graphics, animation, and/or audio data. CD-ROM, for example, launched in 1985 can store the contents of 1,200 standard floppy disks, 5,000 real-life images, or 150,000 pages of text (Helsel, 1991). The current bane of these media is that none can store and play full-screen, full motion video (FMV), which is considered to be one of the most dynamic and exciting elements of a multimedia production. A number of variations (i.e. less than a full screen image, fewer than 30 frames per second [fps]) and software compression solutions have been and are being developed, however, and full-screen FMV is reportedly not far off.

Videodiscs. Videodiscs (or laserdiscs) are 12-inch, record-like optical discs that can store 54, 000 or 108,000 frames (on two sides) of analog format video or images, or 30 minutes to one hour's worth of full motion video (Burger, 1993, p. 486). The audio tracks store CD quality digital audio, and the medium is much more durable than magnetic videotape. Various production methods used to create videodiscs means that some discs differ in terms of the degree of interaction with the content that is possible. In addition, a videodisc player and separate (TV) monitor are required for a videodisc system set-up, in which a computer controls the player and the user watches the TV screen for the videodisc output and the computer screen for the program information. Binder (1992) states that videodisc technology has become an accepted standard in museum applications due to the dependability and durability of this medium (e.g., continuously running videos off a videodisc will not degrade the image as it does with traditional videotape), though the fact that videodiscs have been around since the 1970's cannot be ignored as another reason for this penetration (Helsel, 1991, p. 99).

Writeable Optical Media. These media offer the benefits of optical storage along with the ability to "write to," or record on the media more than once (Burger, 1993, p. 487). Both CD's and laserdiscs on the other hand, require a process called "mastering" which allows a one time recording of the data to be stored on the disc. Writeable technologies include write-once, read-many (WORM) drives and magneto-optical (M-O) drives.

The most common multimedia configuration used by the independent exhibit designers on their museum projects were interactive videodisc systems using a touch screen interface. Linear analog video was also frequently used, while CD-ROM was only mentioned by two of these participants and none had used Digital Video Interactive (DVI), a compression technology, or CD-I. These last two development environments were considered to be too new and expensive for consideration by generally budget-strapped museums, however, vendor-sponsored prototypes using each of these technologies have been implemented in museums. Intel sponsored the *Palenque* project which used DVI compression of video to create an exploratory and educational multimedia program on a Mayan ruin in the Yucatan peninsula. Created by Bank Street College and General Electric's David Sarnoff Research Center (GE sold the DVI technology to Intel in 1988, Pring, 1992) in 1985 as a prototype, the program teaches users about the rain forest, hieroglyphics and other Mayan topics (Bearman, 1992; Wilson, 1987, 1990, & 1992a; Mintz, 1991). Two projects sponsored by Philips, creator of CD-I, include a videodisc on VanGogh as well as a CD-I program on golf for the Golf Museum of the UK (Bearman, 1992, p. 122).

Interestingly enough, when the museum participants were asked about specific technologies they had implemented recently (the last three to six months), most responded that they had implemented some sort of interactive computer systems, *not* using videodiscs - possibly reflecting negatively on the longer development time or greater hardware requirements necessary for videodisc installations (see Table 10). These included computers using HyperCard programs, Director movies, and other hard drive-based interactive programs (more on these in the next section on software). However, videodisc systems were the most frequent response to the question of what projects the museum is currently working on or about to implement. A variety of other platform and peripheral/interface technologies were mentioned, with some of the newest technologies being virtual and artificial reality simulation environments, digital video and audio, networked computers, and Compact Disc-Interactive (CD-I) systems.

The Boston Computer Museum is reportedly one of the few museums to have featured VR technology. Visitors wear a helmet with small video screens in front of their eyes, and computer-generated images of rooms or other spaces are projected onto the screens to give the visitor the sense that they are in the space being projected. (Muro, 1992; Interview: The Boston Computer Museum, 1992). Tech 2000 also has an artificial/virtual reality exhibit called *Mandala* that uses a camera to transmit the visitor's body movement onto a screen. To the participant, the system makes it look and sound as if he or she is playing a series of musical instruments that are in front of the visitor, but which really only exist in the computer's simulation (Schneider, 1992; Interview: Tech 2000, 1992). Another VR project is underway at Brevard Community College which will put virtual reality into its science museum, Astronaut Memorial Hall, as well as other science centers. Its VR exhibit, titled *The Spirit of Exploration* will allow participants to explore other worlds as well as our own, using a completely computer-generated environment and typical VR hardware (Lantz, 1992).

Table 10
What Technology Have You Implemented Recently in Your Exhibits?

What technology have you implemented recently	art	hist	chld	sci	oth	ttl
	Totals by museum type					
New interactive multimedia (not videodisc)		1	3		1	5
No specific plans in place recently	1	1		1		3
None	2	1			1	4
Videodisc	2		1			3
Touch screens		1		1		2
Bar code technology				1		1
Blue screen/artificial immersion environment			1			1
Atari driving simulator				1		1
Computer used to track visitor results			1			1
Amiga Computer projects				1		1
Digital audio			1			1
A/V programs			1			1
n/a		1	1			2
Percent of responses by category	19%	19%	35%	19%	8%	26
Working on/about to implement						
Videodisc	3		1	3		7
Virtual reality				2		2
Would like to use DVI or CD-I	1			1		2
CD-ROM		1				1
CD-I				1		1
Video for museum orientations				1		1
Digital video editing				1		1
Interactive multimedia			1			1
Networked computers				1		1
Would like to do more videodisc				1		1
Percent of responses by category	22%	6%	11%	61%	0%	18

Multimedia Software

Even more important than the hardware used in multimedia programs is the software which allows the designer to create an environment for the user to interact with. Software used in interactive multimedia systems ranges from numerous off-the-shelf packages to customizable programming languages. The main software categories needed to produce a multimedia production are the capture software, used to record the text, audio, images, etc; the programming or "authoring" tools, used to place the information into a programmed sequence of events; and the interface/screen design tools used to present the information in the program. The first and last software categories are simply too numerous to detail, and fortunately are fairly self explanatory. The authoring programs, on the other hand, are the media integration software that rest at the core of any interactive multimedia program, and so will be briefly discussed.

Programming software is what the designer uses to construct the interactive program. All the instructions the computer needs to know in order to show the correct screen of information, to know when to access an attached videodisc player or CD-ROM, or when to wait for the user to respond, are stored in the program's code. Since programming can be a very complex task, many multimedia producers are choosing to use the easy to use authoring (another word for simplified programming) tools such as HyperCard, MacroMind Director, IconAuthor, Linkway, Toolbook, or Authorware over structured languages like C++ or Pascal. Most of the authoring programs are based on a simple premise of allowing the user to decide what information is shown on each screen (like the page of a book), be it text, graphic, video, etc. Each screen, or any element on the screen (generally words or graphics) can then be linked through simple commands to other sequential or related (and not necessarily linearly placed in the program) information. An infinite number of links can be created, including links to sounds, animations, and external devices such as videodiscs.

Authoring languages have made it much easier and affordable for museums to introduce computer technology because they allow museum professionals to construct computer-based interactives geared to their visitors, without requiring sophisticated programming expertise. In addition, these programs can be used to repurpose existing information into a new program. For example, a videodisc of collections from the Louvre Museum could be repurposed by selectively displaying only the impressionist paintings on the disc into a new, separate program sequence. This usage of existing content drastically reduces the cost of creating a new interactive program because it allows the museum to use commercially available videodiscs. Copyright has also become a serious issue in the digital repurposing arena where illegal duplication and image manipulation are easily accomplished, though for museums this is not a problem until they try to sell or distribute the reconfigured material.

Table 11

What Authoring/Programming Software Do You Use?

	Totals by museum type					
Authoring or programming languages preferred/used	art	hist	chld	sci	oth	ttl
HyperCard	1	2	3			6
MacroMind Director	2	1	1	1		5
Use quite a few off the shelf programs			1	2		3
Mostly custom programming				2		2
Use HyperCard the most/a lot			1		1	2
SuperCard	1		1			2
QuickTime	1		1			2
Don't know	1		1			2
Use HyperCard & Director the most				1		1
Authorware primarily	1					1
IBM Infowindow				1		1
AimTech - IconAuthor		1				1
n/a		3	2			5
Percent of responses by category	**21%**	**15%**	**33%**	**27%**	**3%**	**33**

Off-the-shelf authoring tools mentioned most often in museum interviews included HyperCard and MacroMind Director, because both are powerful (though in slightly different ways) and relatively easy to use (see Table 11). HyperCard is currently free with any Macintosh computer purchase, though the features that allow you to create multimedia programs (e.g., special subroutines that allow a HyperCard program to control a videodisc player) require additional spending. MacroMind Director is often used for its animation and sophisticated media integration capabilities (i.e., ability to control external devices such as a videodisc player). On the IBM/compatible side, there was no real consensus of the most popular programs used, but IBM's InfoWindow and AimTech's IconAuthor were among those mentioned.

Putting it all Together

In addition to selecting software and hardware, the museum needs to employ a team of individuals who can put the entire multimedia production together. The talents required to do this are substantial, yet not out of the reach of any museum exhibit staff member who is driven to learn about the technology. In the sample of museums interviewed, all or most of the interactive exhibits were created in-house by the exhibit design staff, with a few museums sub-contracting out for specialized services, such as video production (see Table 12). Those who indicated that they had used independent exhibit designers to create their technology-based exhibits were generally new to using interactive technology, and therefore, could not justify hiring permanent staff with the necessary skills. Four museums mentioned the New England Technology Group (NETG) as a reputable or well known independent design firm, while there was little consensus over any of the other independent firms mentioned. In all cases however, the museum staff worked closely with any outsiders on the design concept and content.

Table 12
Who Created the Interactive Technology-Based Exhibits?

	Totals by museum type					
Who created these interactive exhibits	art	hist	chld	sci	oth	ttl
All/Most done in-house	3	2	4	5		14
Outside contractors (idea & content in-house)		1			2	3
Combination in-house and outside contractors	1	1		1		3
Hope to do in-house				1		1
n/a	1	1	1			3
Percent of responses by category	**21%**	**21%**	**21%**	**29%**	**8%**	24