land masses and life worldwide, and is composed of several activities geared toward children between 10 and 12 years old. "Save the Beach" is a simulated newscast of a hurricane that gets related to the issue of coastal soil erosion. "Continents on the Move," "Shakes, Quakes & Hot Spots," and "Journey to the Sea Floor," are the three other segments of this program that allow visitors to randomly explore issues related to tectonics. The most recent IVSC videodisc is on medical technology, and more are expected in the future (Tillotson, 1991; Interview: Museum of Science, 1992). The individual programs can also be purchased by other museums for approximately $20,000 each, not including about $11,000 in hardware (Binder, 1992, p. 23).

At this point it would seem probable that cognitive research will continue to support the use of interactive media in learning environments. A substantial amount of cognitive research has shown that although there are certain features that characterize the learning process, (e.g., young children are able to learn language by listening to sounds repeated), individuals learn, remember, perform, and understand in different ways (Gardner, 1991b). Multimedia can present information through text, graphics, video/animation, numerals, music, and other creative combinations of linguistic, visual, or auditory means, thereby offering the user the choice of the medium that is best for them to learn by. This flexibility to respond to individual learning styles is a strong argument for educational multimedia technologies. Yet even though many of the museum interviewees for this research believe in the educational possibilities of multimedia systems, at this point they seem more comfortable supporting the widespread use of interactivity in general, both with and without technology.

The Future of Interactive Multimedia in Museums

The results of this research show the use of technology in exhibit design to be most evident in science, natural history and children's museums (Cassedy, 1992; Nairne, 1992, p.19), yet according to Besser (1991) the museum community in general has lagged behind both businesses and libraries in taking advantage of new technologies. Communications scholar Everett Rogers would call them "late adopters", which describes the majority of individuals who will wait to adopt a new innovation until they learn of successes of their peers in using the technology (Williams, Rice, & Rogers, 1988;). There is now a mixture of museums which have not taken their first steps into the world of technology-based exhibits, and those in which technology is deeply entrenched (Bearman, 1991; Binder, 1992; The High Tech, 1992; Mintz, 1992).

Some, particularly the children's museums which have been mesmerized by technology in the past, are now taking a step back to look for the most effective low tech option before jumping to interactive multimedia (Cassedy, 1992; Mintz, 1992; Interviews: The Austin Children's Museum, 1992; The Tech Museum of Innovation, 1992). This more cautious and rational approach is apparently beginning to lead to better designs. Several museum participants commented that computer interactives are now becoming more layered and creative in the ways that they are being utilized. As museums go from project to project, they

will collectively get better at designing, and the real potential of multimedia applications in museums may yet be realized.

In many cases the museums that are hesitant or indifferent about technology have moved toward using a greater variety of both new and established exhibit techniques, such as theatrical exhibits (participatories), creative hands-on activities and artifacts, as well as interactive technologies, to provide the most rounded, diverse, and enjoyable experience for visitors (Cassedy, 1992). Some museums place interactive technology on the same level as other engaging and educational forms of interaction, such as a mechanical hands-on or participatory exhibit, and others recognize technology as providing unique capabilities that can enhance learning in many circumstances more than traditional exhibit methods (Mintz, 1992; Interviews: The Art Institute of Chicago, 1992; The Austin Children's Museum, 1992, Museum Education Consortium, 1992). The resulting status of technology in the museum field appears to be mixed, but many museums and each of the participants interviewed for this study feel that technology can provide an engaging communication alternative that is sometimes much more powerful than traditional interpretation techniques.

Of the museum participants interviewed, over half described the success of their first technology-based interactives as *very successful* or *extremely successful* (see Table 20). Interactives in this case refer largely to computer-based interactives, although in a couple of cases mechanical interactives were also included in these positive responses. The reason most museums gave the technology-based interactives such high ratings was due to their popularity with visitors. *None* explicitly mentioned the educational value of multimedia. The lower ratings of "successful" and "somewhat successful" were given in the situations where older interactive technologies and designs were used, which incorporated only meaningless button pushing as interaction, or were simply not very well designed.

This question logically raises the issue again of what makes an exhibit a success. If people love it but are not learning anything specific or identifable, is it a success? If only a very small portion of the audience uses it and takes some sort of learning away, is it a success? The answers, of course, depend on the respondent's philosophy and exhibit objectives, but for the most part these participants felt that if the exhibit received positive comments and/or people *seemed* to enjoy it (based on staff observations), that would constitute success whether or not visitors retained any specific information from the exhibit. Others, most often from children's and science museums, described their hope as to "instill curiosity", to "encourage the visitor to explore", with specific learning being a more secondary objective, almost invisible to the visitor. The determinants of success are in effect, very personal to each visitor since each brings a different set of motivations, interests, and contexts. Exhibit designers generally ask themselves: did the visitor get something out of it? If the answer is yes, that's really all that matters, regardless of whether the "something" was enjoyment or learning.

Table 20
How Would You Describe the Level of Success of Your First Interactive Technology-Based Exhibits?

	Totals by museum type					
Describe the level of success of the first interactives	art	hist	chld	scl	oth	ttl
Very successful	4	4	1	5		14
Extremely successful		1			1	2
Successful			1		1	2
Somewhat successful				2		2
Not sure of 1st ones, but as whole would describe as very			1			1
n/a	1	1	2			4
Percent of responses by category	**20%**	**24%**	**20%**	**28%**	**8%**	25
Why given that rating						
Visitors love/enjoy interactives/interactives were popular	1	5	3	5		14
Comments from visitors/educators	4	2			1	7
Were the reasons for repeat visits to the museum		1			1	2
Earlier exhibits needed some modification/improvement				1	1	2
Visitors returning to same exhibit			1			1
Visitors examining artifact on which interactive was based	1					1
Earlier interactives had too much meaningless interaction				1		1
Percent of responses by category	**21%**	**29%**	**14%**	**25%**	**11%**	28

Note: As only a few museums have ever done formal evaluations of exhibits, the majority based their response to this question on informal observations and visitor comments. All of them felt quite confident in doing so.

Computer-based technologies are actually serving a number of different museum functions from conservation, restoration and preservation; to security, collections, financial, and visitor information management; to outreach programs for schools and teachers, and of course, as a medium for exhibition (Besser, 1987; The High-Tech, 1992; Mintz, 1992). Technology is also bridging the gap between these museum functions. Many museums are using computers and videodisc technology to catalogue their collections, which serves as a form of preservation, security, and information management, and can later be converted into visitor-controlled exhibits (Besser, 1987; Binder, 1992; Interview: Museum Education Consortium, 1992). Digital databases of artifacts and specimens are allowing the museums to show the public their entire collection, the majority of which is often not displayed because of space limitations. Another convergence of museum functions is happening with the installation of computers or videos that provide interactive tours or maps of the museum - allowing visitors to get their bearing and not be overwhelmed by the diversity of topics or number of galleries, while freeing staff and providing a more dynamic alternative to printed brochures. Bearman (1992) has categorized the above descriptions and others into the following ten categories of museum multimedia applications (p. 125).

Directories, Orientations, and Tours: Bearman refers to these as some of the first applications of multimedia in museums. Fairly self-explanatory, the main purpose of these interactive applications is to help users plan their path through the museum, or take a tour.

Collections Information Data/Imagebases: Visual documentation of museum collections and related information are perhaps the simplest, least expensive, and least common of the multimedia applications. Bearman notes that these databases could serve as a huge source of content for new multimedia programs, but that few museums aside from those with large photographic archives are attracted to this category.

In-Depth Study: These interactives focus on allowing the examination and study of one or a few objects usually found in the museum, in a depth that would only be feasible for a visitor who had access to a computer. The *Visitor Information Prototype* and *Palenque* videodiscs mentioned earlier are two examples of in-depth study.

Interactive Installations: These are the most familiar applications of multimedia in museum exhibits, and refer to most of the exhibits that have been described throughout this report. Their purpose is to allow visitors to selectively interact with and learn about the contents of the computer program.

Museums without Walls: This application refers to the ability of interactive multimedia to eliminate the obstacles of the remote, handicapped, or foreign visitor, by presenting information in multiple languages, levels of complexity, and modalities (e.g., the ability of videodisc to store multiple language tracks, or computers to turn audio on and off). Traveling exhibits have also served to remove exhibits from the originating museum's walls and bring the experiences to remote locations.

Participatory Experiences: These exhibits provide visitors with simulated environments in which to interact and explore. The *VIDEOPLACE* exhibit mentioned earlier was an example, as is the *Tactile Dome* at the Exploratorium in San Francisco, which allows visitors to roam, slide and crawl through a darkened tactile-rich maze.

Public Spaces: This category refers to a new genre of public interactivity that is beginning to take place. Bearman provided the example of the IBM Gallery of Science which installed a huge touch screen in a gallery window to encourage the public outside to participate in the exhibit.

Tools: Multimedia tools can serve to simplify museum staff responsibilities and improve visitor experiences. Examples are computer-aided design (CAD) programs which allow museum staff to plan exhibit layouts in 3-D, and imaging technology that can increase the efficiency and accuracy of research and con-

servation efforts. Both can also be used in the actual exhibits to enhance visualizations of the content.

Publications and Products: As was mentioned in several museum projects, museums can package and resell the content that they capture and organize into a multimedia programs to a consumer market.

Networking: Between exhibits and across museums, networking of information and experiences is now possible. Bearman mentions that several firms in the United States are interested in networking databases of museum images, and one is providing on-line access to art auction catalogs.

Bearman concludes that there is substantial interest and potential for multimedia in museums and that most of the world's largest museums have experimented with interactive technologies, as have a substantial number of smaller museums (p. 122). However, similar to the participants in this study, he feels that the possibilities of these technologies are far from being realized in museums. Furthermore, most of the museum multimedia applications are one-shot projects rather than components of a long-term information technology strategy. This will most likely change if and when a consumer market for multimedia develops, and at that point more museums, as enormous content (i.e., multimedia information) holders, may fully recognize the opportunity they present to multimedia producers. Until then, the evaluation of what has been accomplished and what can be done with multimedia in museums, needs to become an on-going and serious endeavor. Nairne (1992) goes as far as to state that "the field will not develop properly unless new and exciting interactive programmes are demonstrated in use: only this will convince senior curators and directors with control over budgets" (p. 25).

The proliferation of increasingly affordable electronic technologies into all facets of our lives has made it difficult for museums to resist integrating technology's capabilities as both media and modes of exhibition. For the children of the video-age, multimedia offers a stimulating and interesting educational experience that can go far beyond what is absorbed by reading labels, and it has the attracting and engaging power that allows it to compete with television, video games and similar electronic entertainment pastimes (Alexander, E., 1979; Mintz, 1992; Special Focus: IBM, 1991). Considering the very positive results that many educational multimedia applications are enjoying in both museums and formal learning environments, (Bearman, 1991; Cassedy, 1992; Cooper & Oker, 1991; Hokema, 1991; Wilson, 1991, 1992a & 1992b), it is not surprising that these technologies have been able to penetrate museum walls. There may not be any true consensus among museums that more technology is better, since as in any design problem a number of issues regarding the costs and benefits must be considered. But the interest in multimedia definitely exists in the museum community, and new projects using technology are being implemented all the time (Bearman, 1991 & 1992; Binder, 1992; Special Focus: IBM, 1991).

Many of the museum participants have specific plans to incorporate more interactive technology-based exhibits in the future, while others are planning on an increase in any type of interaction, mechanical or electronic (see Table 21). They also plan to continue using the same acquisition method, that is, most of these museums will continue to design their exhibits in-house. Their motives for wanting to use more interactive technology are based on all the reasons that have been presented thus far: interactive multimedia technologies offer an alternative, dynamic, engaging form of exhibition. Only one art museum participant indicated that it does not plan to use technology until prices come down and space allocation design problems specific to the art museum environment can be addressed. Other participant plans include using technology to enhance existing exhibits, and for several art museums, marketing videodiscs of art collections and related art history information to other museums, schools, and interested parties.

Table 21
What Are Your Current/Future Plans for Incorporating Interactive Technology in Your Exhibits?

	Totals by museum type					
Current/future plans for technology	art	hist	chld	sci	oth	ttl
Plan more interaction w & w/o technology		3	2	3	1	9
Have specific plans to incorporate interactive technology	2	2	2	3		9
Plan to market/give our systems to schools, museums, etc	3				1	4
Plan to enhance existing exhibits w/technology		2		1	1	4
Will incorporate more interactive technology, no plans yet	1			1	1	3
Have plans for a mechanical interactive		1	1	1		3
Plan to use technology in new creative ways			1			1
No plans, it's too expensive	1					1
Percent of responses by category	**21%**	**24%**	**18%**	**26%**	**12%**	34

Museum participants from all categories also expect and/or hope that the use of interactive technology will expand dramatically in future museum environments (see Table 22a). Art museum respondents sometimes added that the use of technology in their museums will take a slower pace than in other museums, as they feel there are fewer ways to utilize the technology in that environment. In addition, they indicated that there is greater resistance to technology in the traditionally organic, quiet, contemplative environment of art museums. Three children's museums, one history, and one science museum added that technology's use will expand along with the creation of other interactive methodologies such as new hands-on experiments, group activities, participatory experiences, etc.

Table 22a
What Do You See As the Future Role of Interactive Technology in Museums?

	Totals by museum type					
Future role of interactive technologies	art	hist	chld	sci	oth	ttl
Think &/or hope it will expand dramatically	3	3	2	6	2	16
Think will expand along w/other interactive techniques		1	3	1		5
Even art & history will use technology more & more	1			1	1	3
As museum expertise improves, usage will grow	1		1			2
Will see more bad solutions until museums build expertise		1				1
Will grow slowly as price decreases & technology improves	1					1
n/a		2	1			3
Percent of responses by category	**19%**	**23%**	**23%**	**26%**	**10%**	31

When asked if anyone had a "dream exhibit" for the future, only a couple of specific examples were mentioned. An exhibit designer from a children's museum who had some experience using technology to provide direct and recorded links with a Japanese museum wished to expand this effort to link up with other foreign countries. This would be an application that combines the "interactive installations" and "networking" categories of multimedia in museums described earlier. A history museum exhibit designer mentioned two installations which he felt all first class museums of the future will have, both of which fall into the category of "directories, orientations, and tours". The first is a touch screen navigation system that would allow visitors to locate anything as they enter the museum, or relocate anything they have just seen anywhere to find out what it is, what it does, and where it is. A related touch screen data and image base would be located near the artifact it describes, provide a great deal of information on the artifact, and allow the visitor to view all sides of the object.

Eight of the museum interviewees responded that they felt the long term use of technology would complement artifact-based or non-electronic exhibits (see Table 22b). These participants were able to rattle off a number of synergistic reasons for this opinion: computers give a much greater interpretive potential to the artifact; there are unlimited interpretation possibilities with computers; multimedia programs allow customization for different levels and modes of learning; technology provides access to greater amounts of information; and technology will increasingly allow the visitor to take part of the museum experience away with them, in the form of a printout, or perhaps by buying a videodisc of a collection. A technology museum participant went so far as to say:

> *In a way technology does threaten traditional artifacts, but it's not really a bad thing to have more interesting treatment that is also more accessible. It also represents a good step toward moving away from the elitist snob factor (of traditional museums) - it's a move toward democratization (in museum exhibitry).*

Table 22b
What Effect Do You Think the Long-Term Use of Interactive Technology Will Have On Traditional Exhibits?

	Totals by museum type					
Long term technology affect on traditional exhibits	art	hist	chld	sci	oth	ttl
Will complement/enhance traditional-artifact exhibits	2	2	1	2	1	8
Both will always have an audience (exist separately)	1		1	2	1	5
Difficult question to answer	1	2				3
Think technology has had a negative effect				1		1
VR could change way museums operate, but not artifacts			1			1
n/a	1	1	2	2		6
Percent of responses by category	**21%**	**21%**	**21%**	**29%**	**8%**	24

The only negative comment about technology's effect on artifacts was felt by an individual who had seen computer-based designs which did not link the exhibit content to the actual artifact or historic element it was attempting to explain. If not well designed, he felt, technology could detract from the experience with the artifact. A few other participants also commented that they felt this could become a sensitive issue. A children's museum warned that exhibitors will really need to think about how they are presenting information, and how they are linking and combining the technology with the "real thing".

In addition to the learning and communication issues that are most commonly mentioned, there are economic reasons to incorporate interactivity and technology in museums. In the past few years, donations and funding have become much tighter and visitors have become increasingly demanding in terms of the level of information they expect to gain from a museum visit (Alsford & Granger, 1987; Gable, 1992; Hudson, 1977; Interview: Bank Street College of Education, 1992). Hypermedia digital storage and retrieval of artifacts can provide a two-fold solution to the problems of satisfying visitor interests and providing careful handling of the artifacts (Bearman, 1989). Since digital technology can provide almost instant access to huge amounts of information, visitors can find the information they are looking for more easily and quickly than if they were to ask a museum employee or if they had to research it themselves. In addition, digital systems avoid display of the actual artifacts, allowing objects that cannot be exhibited due to display space limitations and conservation restrictions to be "virtually" displayed within the computer.

Use of multimedia technology in exhibits can also act as a marketing tool. As a leisure time activity, museums must compete with a plethora of alternative pastimes, from reading a book to attending a sporting event. As an educational activity, museums must present information in ways that can be assimilated by very diverse audiences. Because people are attracted to different things and learn in different ways, museums have had to develop exhibits that both attract the audience's attention and cater to multiple learning styles. Apparently, it is largely the younger generations (under the age of 30-35) who are driving the challenge to develop audience attracting devices such as multimedia exhibits (Mintz, 1992;

Interview: The (Boston) Computer Museum, 1992). Because this generation is so acclimated to the visual and aural stimulation from television, movies, music videos, computer games, and other products of this electronic age, they have raised expectations for all types of every day activities and demand greater stimulus to gain their attention (Mintz, 1992). Interactivity and interactive technologies have helped address the issues of how to increase attendance, fulfill educational goals, get the visitor's attention, and at the same time encourage visitors to ask questions and discover learning on their own.

Increased degrees of interactivity were what participants thought of when they were asked what trends they expect to see in future exhibit designs. The most common response was an increase in the use of *virtual reality* systems, followed by a related but more general description of more *participation/immersion exhibits*, and more group or *multi-user exhibits* (see Table 23). On the other hand one children's museum mentioned the possibility that there will be virtual reality systems in the home, therefore, museums will be needed to continue to serve as the physical experience. A history museum noted that because VR is unfamiliar to many individuals, it risks putting visitors off-balance and losing their context for learning. The science museum participants were the most verbal about future possibilities, again logical given the fact that they are among the largest users of technology in museums and because they have done the most in-house design.

Table 23
Do You See Any Trends Toward Future Exhibit Designs?

	Totals by museum type					
Trends/expectations for future exhibit design	art	hist	chld	sci	oth	**ttl**
VR, especially as technology improves, could become big	1		1	3		5
Participation/immersion will increase		1		2		3
Group/multi-user activities and exhibits will increase				2	1	3
No trends, just expect new developments		2				2
More meaningful interaction			1		1	2
More multimedia as price drops & tools more reliable/easy		1			1	2
Networking exhibits and museums	1					1
Don't know	1	1		1		3
n/a	3		2	1		6
Percent of responses by category	**22%**	**19%**	**15%**	**33%**	**11%**	27

One of the final questions asked of participants was what research question(s) about interactive technologies they would like to have answered. Museums most commonly responded with questions about to how to best use the technologies, or about the educational properties of the medium (see Table 24). Responses within these two generalizations were somewhat varied, with at most three museums posing the same specific research ques-

tion. The two most popular questions asked *whether technology really enhances learning*, and *how to design good interactive technology exhibits*. The opinion of the association participants interviewed was that most museums want to know *what technologies are available, how to use them*, and *how much it costs* to implement these technology-based systems. (See Appendix C for tables of the Associations and Experts responses.)

Table 24
What Research Questions Regarding Interactive Technologies in Museums Would You Like Answered?

	Totals by museum type					
What research question would you like answered	art	hist	chld	sci	oth	ttl
Whether technology really enhances learning		1		2		3
An interactive technology design rule book	1		1	1		3
How to use computers in new, more creative ways		1		1		2
A list of reputable exhibit designers			1		1	2
Visitor studies info (e.g., reactions to technologies)	1	1				2
How to integrate the different media into exhibits				1		1
When to use the different technologies (media selection)			1			1
How many institutions use technology					1	1
What interactive devices are other museums using		1				1
How other museums use interactivity & is it a success		1				1
What form will HDTV come in	1					1
Information about interface evaluations				1		1
What's the cost effectiveness of in-house vs. contract design				1		1
Do you need quizzes for it to be educationally successful		1				1
Information on successful mechanical interactives					1	1
How much feedback is appropriate for this environment					1	1
How to structure hypertext experiences					1	1
Can't think of any questions	1			2		3
n/a	1	1	2	1		5
Percent of responses by category	**16%**	**22%**	**16%**	**31%**	**16%**	32

A review of these questions helps support earlier assumptions that many of the museum participants are not aware of the studies that are available on the successes of interactive multimedia in education and training, nor of the books on exhibit design and use of technologies, nor of the visitor studies research. Although the level of information about how to use new technologies specifically for exhibit design is only now beginning to grow, some useful information does exist of which the interviewees were unaware. A starting point is the bibliography for this report.

This lack of information may very well be due to information overload. Too many changes are happening in the technology industry and too many sources need to be checked for a museum professional to form a rounded picture of what's being done, proven, or available. This information is not currently gathered into a comprehensive "multimedia in museums" journal, although technology and technology-based exhibits are increasingly featured in museum journals such as *MuseuMedia*, and publications such as *Archives and Museum Informatics*. Another reason for the perceived lack of information may be that the information available is not specific to museums because: 1) technology is not marketed to museums; 2) museum experience with technology is still relatively new; 3) museums do not publish enough about their individual experiences with technology; 4) museums are still trying to work out their own genre of interactive technology.

Though the feelings and opinions of participants included in this report are, for the most part, very positive toward the current and future use of interactive multimedia in museum exhibits, there are a number of barriers that will need to be overcome before the dreams to fully utilize multimedia can be realized. Lack of standardization across multimedia platforms and compression algorithms, lack of an international copyright procedure for digital media, inefficiencies in the current technology's methods of storing, compressing, playing-back, and transmitting (via telecommunications) multimedia information, uncertainty about how best to communicate using these new tools, and the current recession, are only some of the factors (many not even recognized by the interview participants in this study) that will continue to complicate the efforts of museum staff to integrate technology into their environment (Bearman, 1993; Francis, 1992; Pring, 1992). Nonetheless, the support for and interest in multimedia continues.