visitor, though proactive modes would be helpful to researchers, scholarly visitors, and museum staff.

By capitalizing on engaging and stimulating educational techniques, with or without computers, museums not only help individuals understand significant and relevant information, they help them assume responsibility for their own learning. The *What If?* gallery that recently opened at the Indianapolis Children's Museum has interactive multimedia exhibits as well as simple hands-on activities. The learning strategy is to prompt visitors to learn by asking them "what if?" questions, and then allowing them to explore various simulated environments that contain answers to the questions. One exhibit asks "What if you could discover a dinosaur?" and then lets children play archaeologist and dig for bones. Another exhibit asks about communication in Ancient Egyptian exhibit and then teaches kids how to decipher hieroglyphics. (Ogintz, 1992a; Interview: Indianapolis Children's Museum). No matter what medium of information presentation is employed, it is the interaction with the information that leads to learning.

Exhibit 4
Levels of Interactivity

Type of Interaction	Level of Control Over Learning	Electronic/Mechanical Interaction
Hands-on	low	mechanical
Participatory	low to medium	mechanical & electronic
Interactive	low, to medium,to high	mechanical & electronic
Reactive	low	electronic
Interactive	medium	electronic
Proactive	high	electronic

Note: These are generalized interpretations made by the author of this study based on the types of interactivity described by Bitgood (1991) and Lucas (1992).

Interactive Multimedia in Museums

Museum participants in this study have had varying lengths of experience with computer interactives and interactivity in general. Of the museums interviewed, most of the science museum participants stated that they have had all types of computer-based interactives since they were opened, and many of the children's and science museums reported "always" having had some form of interactivity (mechanical or electronic) in their exhibits (see Table 14a). Several of the children's museums who have had substantial experience with interactive technology-based exhibits state that their primary focus is on mechanical interactives. One children's museum stated the importance of interactivity in this way: *our audience (lar-*

gely children) deems hands on interaction to be highly necessary, because that's the way they learn, by being involved and immersed in doing something physically. Technology was certainly not a prerequisite for interactive children's interactive exhibits. Interviewees from associations and independent exhibit design firms stated that this was true for art museums because many of them are still technophoblic and/or focused on collecting and preserving over education. However, a number of participants also felt that art museums have and will increasingly use interactive videodisc technology to create visual databases for collection as they come to recognize that well designed videodiscs are an alluring, economic, and efficient way to display art museum collection.

Table 14a

What is the History of Interactivity in Your Museum?

	Totals by museum type					
What is the history of interactivity in this museum	art	hist	chld	sci	oth	ttl
Have always had computer interactives		1		5	1	7
Now have both computer & mechanical interactives		1	3	2	1	7
Don't have any/much of a history of interactivity	3	2				5
Have (almost) always had mechanical/physical interactives		2	2			4
Fairly recent	2				1	3
Have no computer interactives at this time			1	1		2
n/a		1				1
Percent of responses by category	**17%**	**24%**	**21%**	**28%**	**10%**	29

Many of the museums interviewed first incorporated interactive technology because they *already had an interactive focus* and interactive technology was a natural extension of this philosophy, or because a *staff member championed the idea* of an interactive technology-based exhibit (see Table 14b). Several also mentioned that *technology was the logical solution* to an exhibit problem, showing these museums to be aware of its capabilities, versus under pressure to "computerize". Although these were the reasons why technology was used in the exhibits, the driving arguments for incorporating technology were visitor centered, having to do with the appeal of multimedia technology and the possibilities for information that it offers visitors.

Table 14b
Why Was Interactive Technology Incorporated Into Your Exhibits?

	Totals by museum type					
Why was interactive technology implemented?	art	hist	chld	sci	oth	ttl
Have always had an interactive focus			3	6		9
Idea/champion(s) in museum wanted to use technology	2	2		2	1	7
Technology was the logical solution to exhibit problem	1	2	1			4
Received grant/funding/donation to do a technology exhibit	2	1				3
Technology appeals to the audience		1			1	2
Visitors wanted more information		1			1	2
n/a	1	1	1	1		4
Percent of responses by category	**19%**	**26%**	**16%**	**29%**	**10%**	31

While many of these participants share the belief that doing something is more educational than seeing or reading about it, and while a number of studies have shown that the use of interactive multimedia systems offers a more effective learning approach than traditional teaching techniques, technology is not considered by all museum professionals to be the panacea for every design problem, nor do they feel it can replace or hold the significance of the actual artifact (Cassedy, 1992; Helsel, 1990; McCarthy, 1989; Mintz, 1992; Muro, 1992; Ogintz, 1992a; Rist, 1992; Schneider, 1992; Special Focus, 1991; Ten Million, 1992; Wilson, 1987, 1991 & 1992a; Interviews: The Austin Children's Museum, 1992; The Exploratorium, 1992; UCB Art Museum, 1992). Instead, incorporating interactivity in general, not necessarily through technology, appears to be the primary focus of museum exhibition (Abbe, 1992; Feber, 1992; Harte, 1989; Information Technology, 1992; Maes, 1992; Ogintz, 1992b; Interviews: The Austin Children's Museum, 1992; The Exploratorium, 1992). Museums see interactive multimedia technologies as a means , but not the only means to incorporate interactivity into exhibits.

National Geographic's Explorer's Hall, for example, opened reportedly one of the most advanced interactive science centers featuring both mechanical and electronic interactives (Harte, 1985). The *Geographica* exhibit includes an 8 foot simulated tornado whose mist visitors can touch; a 74-seat spaceship controlled by nine computers that creates an interactive theater presentation from outer space; and use of a remote-controlled microscope that can zoom in on a live chameleon. Every exhibit in Explorer's Hall, even the artifacts, (e.g., photographs) is grounded in a philosophy of interactive learning which engages the visitor by posing a question that can be answered by examining the exhibit (Harte, 1989).

Maton-Howarth (1990) argues that "the greatest involvement is most likely to be manifest in interactive activity centered on the play experience, play being an element central to the creative development of the individual" (p.200). As a mode of exhibition, then, play can be very conducive to learning experiences. Since children commonly employ games in their play-time activities, the museum participants were asked how many exhibits

they would describe as educationally "game-like". Game-like was meant to imply that the exhibit would have some underlying framework which could be in the form of a story or simulation with an established motive that drove the player to progress through the framework. The end result would be that the visitor learns something in the process. An example of this would be the educational game, "Where in the World is Carmen Sandiego?" developed by Broderbund Software. This very successful educational computer program requires learners to play detective using an Almanac to find clues to missing people. In the process, students develop deductive skills while they learn about history and geography.

Of those who responded to this question, four museums said they try to incorporate a lot of game-type activities because games successfully attract and engage visitors, and two said they stay away from games completely because they don't consider games an appropriate mode for their topics or for museums in general (see Table 15). Just over half, more commonly the children's and science museums, reported having at least some game-like exhibits. Again, a result that makes sense given their audience and the visitors' motives for coming to children's museums.

The term "game-like", however, turned out to be rather subjective and several museums felt the need to use a different term. The initial purpose of this question was to find out whether or not many exhibits used the game-like qualities described above to attract and engage the visitor, and while some of these same qualities exist in their exhibits, many participants felt more comfortable with the other descriptions mentioned in Table 15. When given the opportunity to describe the various modes of information presentation used in their interactive exhibits (both mechanical and computer-based) in other ways, many used the phrased *discovery-based* or *exploratory learning*, and *activities with problem solving goals*.

Table 15

How Many Exhibits Would You Describe as Educationally "Game-Like?"

	Totals by museum type					
How many are (educationally) game-like?	art	hist	chld	sci	oth	**ttl**
Just a few (commonly 1-2)	1	1	1	2	1	6
Majority			1	2	1	4
Less than one third			1	2		3
Total reporting at least some as game like						13
Discovery/exploratory learning	1	3	1	5	1	11
Activities/problem solving	1		2	6	1	10
Simulations (includes recorded interviews)	1	2	2	3		8
Narratives/storybooks	2	2				4
Play acting/immersions		2				2
Instructional "how to"			1		1	2
Video games (non-educational)					1	1
n/a	2					2
Percent of responses by category	**15%**	**19%**	**17%**	**38%**	**11%**	53

Each of these descriptions relate to one or more of Maton-Howarth's (1991) critical elements for interactive learning systems. Discovery-based or exploratory learning modes, which imply substantial user control over the information in the exhibit, can provide the motivation, meaning and interaction that Maton-Howarth describes. Activities with problem solving specifically relate to the meaning which she says needs to be incorporate into educational exhibits. Bitgood's (1990) three types of interactivity also relate to these responses. Hands-on, participatory, and interactive exhibits each place the responsibility of learning in the hands of the visitor by giving them varying levels of control over the interaction with, or information taken from the exhibit experience.

Of those who chose not to use the word "game" in describing their exhibits, most agreed that play is a very important element in exhibits because people come to museums to have fun, but they added that fun and play can be achieved without the goals commonly associated with games. Even some children's museums showed preferences for modes other than games: *We try to avoid the game format and concentrate on intrinsically interesting episodes. I think museums need to define their own genre of interactivity and shouldn't take their ideas from other areas (i.e., video games).* Finally, several museum participants mentioned the necessity of considering the content and exhibit objectives before choosing a mode of presentation.

Given the fact that most museum visitors do not visit the museum alone, participants were also asked if their museums had any interactive technology-based exhibits that could simultaneously accommodate more than one visitor. Over half of the museums surveyed had some sort of multi-user exhibit, and all of the respondents agreed that multi-user exhibits should be an important exhibit design consideration. In history and children's museums, these exhibits often included group activities within a simulated (computer-generated or theatrical set-up) environment (see Table 16). Four of the science museums mentioned multi-user exhibit that involved the application of networked computers which visitors could use to create products, or otherwise collaborate to achieve some goal. For example, a new exhibit being developed at The Boston Computer Museum will network several computers so that groups of visitors can collaborate to solve a jigsaw puzzle (Interview: The Boston Computer Museum, 1992). Other multi-user exhibits mentioned included group hands-on science experiments, computerized polling exhibits (i.e., voting on issues), and exhibits that allow visitors to dress up in a cultural costume and walk around a historic setting (Muro, 1992).

Table 16
Do You Have Any Multi-User Exhibits?

	Totals by museum type					
Any multi-user exhibits	art	hist	chld	sci	oth	ttl
Yes, tech. &/or mechanical (e.g., group activities; Mandala)		3	4	1	1	9
Not tech-based but some become multi-user as others watch	3	2	1			6
Yes, computer networked multi-user				4		4
Yes, mechanical multi-user exhibits/group activities	2				1	3
Are considering technology-based multi-user exhibits					1	1
Plan to create more multi-user exhibits in future				1		1
n/a	1			1		2
Percent of responses by category	**23%**	**19%**	**19%**	**27%**	**12%**	26

Six of the museums that did not have networked computer exhibits explained that many interactive computer exhibits *become* multi-user exhibits as visitors stand around to watch the person at the controls. Several of these museums also mentioned that the use of repeat or duplicate monitors (large monitors often suspended above the smaller controlling-interface monitor) intentionally serve the purpose of providing multiple users at least visual access to the exhibit. Although only one individual can interact with the computer, on-lookers are often found directing the actions of the controlling individual and thereby indirectly taking part in the interaction.

Multi-user technologies highlight some of the ways in which exhibits can create new vehicles for interaction. Virtual realities and even much simpler simulations can turn visitors into participants, allowing them to play roles and do things that they might not otherwise experience. By allowing more than one visitor to participate in a virtual or artificial simulation, visitors can interact not only with the information being presented, but also with other visitors. Participants from both museums which have and those which do not have multi-user exhibits mentioned that they are very interested in the potential of multi-user exhibits to provide fun communication and socialization experiences. Here are a couple of the specific comments that were made:

> *I think it's a good idea to have multi-user exhibits, the value of them is something we are coming to recognize. From an exhibition level I think that we should have at least one group activity per exhibition area. However, they are considerably more difficult to design and develop.* (a technology museum)

> *(In our networked computer exhibits) the individual decides whether to work in groups or not. Not sure which they prefer, but we have a concerted effort to create*

more group exhibits in the future because we consider it an important part of our educational goal. (a science and technology museum)

We have Mandala (a computer simulated musical environment) but without a lot of guidance, we're not sure what visitors are learning. People aren't sure how to interpret the virtual space without help, because it's so far out of a normal context to them. (a children's museum)

The fact that interactive multimedia technologies are considered to be so engaging leads to the question of whether or not visitors spend more time with these exhibits, and if so, whether or not they learn more because of the extended exposure. If this were the case, it might justify spending the large sums of money required to develop technology-based exhibits. Unfortunately, the participants felt that the amount of time spent or the amount of learning taking place were difficult questions to answer. Not only can it be very difficult to track the time spent, but participants pointed out that it also does not necessarily indicate anything positive. How long a visitor spends with an exhibit can signal many things to a designer, from indicators about the level of engagement to the clarity of communication. Depending on the content and design, some exhibits simply require more time to participate in than others, and it does not always have to do with whether it's an interactive exhibit of not. For example, videos usually take more time to watch than short chunks of content in a computer program, and a visitor can spend an hour looking at dinosaur bones. And if they do spend more time, is that necessarily better? What does that really tell you as an exhibit designer? It can indicate both good (e.g., they are interested/are learning more) or bad (e.g., they are totally confused) conclusions.

The most common response was that it is very difficult to compare time spent with interactive versus other types of exhibits and in facts, no one interviewed has ever cared enough to formally track it (see Table 17). Other complicating factors include deciding how to count the on-lookers, how to let the computer know if there is a new person using the program, and how to integrate personal factors into the amount of time spent (i.e., if people are distracted while using an exhibit, how do you start and stop the time).

On a more positive side, eighteen percent of the participants felt that visitors did spend more time with the interactives specifically because of the appealing traits of interactive multimedia technologies. Two museums indicated that their informal visitor surveys showed that repeat visits were sometimes due to the fact that visitors wanted to spend more time with the interactives. Then there were those who simply stated that people spent more time with the interactive technologies and for whatever reason, it was a good sign. While these opinions were not based on data from formal studies, they do reflect the experienced opinions of these museum professionals.

Table 17
Do Visitors Spend More Time With the Interactive Technology-Based Exhibits?

Spend more time with interactives? How long?	Totals by museum type art	hist	chld	sci	oth	ttl
Very hard to track or conclude anything from time spent	1	4	3	1	1	10
Yes/think so		2		3	1	6
Don't know	3			1		4
Up to 1-3 hours		1		1		2
From 20 seconds to 1 hour			2			2
3-5 minutes is good goal			1	1		2
From 30 seconds to 15 minutes usually				1		1
Average of five minutes				1		1
n/a	2		2	1		5
Percent of responses by category	**18%**	**21%**	**24%**	**30%**	**6%**	33

Yet some studies on time spent with interactives have been conducted. Melton (1972), for example, conducted a study which supports the opinion that people spend more time with interactives. He found that visitors spent a longer time (average of 23.8 seconds) examining objects when they were able to operate the device, than the average 13.8 seconds they spent when it was operated automatically. Melton claimed this showed increased interest in finding out more about the topic (Melton's study, partially reprinted in Special Issue, 1987a, p.10). Furthermore, one museum participant noted that educational researchers have proven that time spent is correlated to learning, So while it may be difficult for some museums to track this information themselves, the length of time spent with interactive exhibits could very well have positive implications for the use of interactive technologies. Preliminary evaluations of the interactive exhibits at the National Museum of America History also show that visitors spend much more time with the engaging and relevant interactive technology-based exhibits, at 30 minutes on average. (Allison & Gwaltney, 1991).

When the museum participants in this study were asked whether or not they had any evidence to show, or whether or not they simply believed that visitors retained more information from the interactive technology-based exhibits, a good number were hard pressed to answer positively, while half said they believed it to be the case (see Table 18). Two participants knew of research that supported this claim, citing knowledge of studies that have shown interactive multimedia decreases learning time by 50% and increases retention by 50%. In several cases interviewees indicated that visitors have commented that they wanted to examine the art a second time, and more closely, after they had viewed an interactive videodisc that provided background information on the artist, art, materials, etc.

Table 18
Do You Think Visitors Retain More Information from the Interactive Technology-Based Exhibits?

	Totals by museum type					
Do visitors retain more information from interactives?	art	hist	chld	sci	oth	ttl
No evidence/hard to say	1	2	2	2	1	8
No hard evidence, but believe so	1	2		3		6
Believe it enhances the curiosity to learn	1	1	2			4
Yes, know of research (external) that supports this		1		1		2
Believe it depends on the learning style, not presentation			1			1
Doing evaluations now		1				1
n/a	2			2	1	5
Percent of responses by category	**19%**	**26%**	**19%**	**30%**	**7%**	27

The difficulty of evaluation pre and post knowledge levels of a transient audience prevents many museums from gathering visitor comprehension date, not to mention the facts that although many of these participants considered providing information and learning opportunities to be a major goal, few consider their function to be evaluators of visitor learning. Most of the participants mentioned that they would like to have data confirming this hypothesis in order to help justify expenditures for interactive technologies, and several added that they tend to look hopefully toward the academic environments which can more easily provide this type of data. One association participant commented that museums *must stop charging ahead without doing more front end analysis and formative evaluation; museums almost never do either. But as money becomes more scarce, the frequency and sizes of exhibits will be scaled down and will put even grater pressure on success. Evaluation will become an economic necessity.* Several independent exhibit designers agreed with this opinion, and one went as far as to tie the future of technology in exhibits to the justification of its educational value. Other comments further illustrate the participants' views on educational evaluations.

> *We think a number of the interactives here have the potential to be more successful at imparting information, but we're not sure how well they succeed. It's not necessarily the fault of the exhibit (if the visitor doesn't learn), because it depends on what the visitor brings to it.* (a history museum)

> *Being high tech and glitzy, and therefore, more entertaining, may come into play as far as how much they pay attention to it, but beyond that, we don't know how much more thy learn.* (a science museum)

> *It's hard to evaluate, first because we don't have direct comparison data (i.e., same content, pre-and post-test information for technology-based and non-technology-based exhibits). Also, a lot of what happens in an interactive exhibit and the exhibit*

objectives themselves are not information driven, so you aren't looking for traditional educational goals. (a children's museums)

Several participants stated that knowing whether multimedia technology truly increases learning over other exhibit types would encourage them to design using interactive technologies. This becomes a particularly important factor when one considers the cost of a basic multimedia system, which normally includes a computer, high resolution color monitor, CD drive and/or videodisc player, lots of memory, processing speed, and software. Bearman (1992) estimates a basic platform to cost about $6500 (p. 124). On top of that, of course, is the cost to design and develop the interactive system. The independent exhibit designers and museum participants stated that the cost of developing interactive computer exhibits varies dramatically depending on the installation, ranging from $15,000 for a low level videodisc database, to well over $500,000. One independent designer commented that it is difficult to do "anything nice", for less than $40,000 to $50,000, but that the average cost is closer to $50,000 to $200,000. A science museum participant mentioned that the least expensive videodisc that they had produced with in-house design staff cost $28,000, while their average ranged from $60,000 to $100,000, and the really high-end interactive videodiscs cost about $250,000. Binder (1992) has done extensive research into the use of videodiscs in museums, and states that the average cost is from $100,000 to $200,000 but can reach several million (p.8).

Table 19a

What Are the Main Limiting Factors Against Incorporating Technology in Exhibits?

	Totals by museum type					
Limiting factors against using technology	art	hist	chld	sci	oth	**ttl**
Money	4	2	1	3		10
Many museums lack internal design expertise/experience	2	1	3	3		9
Cost of development			2	1	2	5
Unfamiliarity w/technology or its capabilities	2		2			4
Maintenance is a problem for many	1		1	1	1	4
None for us		1				1
Security					1	1
Cost of hardware				1		1
Time to design and develop				1		1
For many, it's seeing bad design/use of technology		1				1
n/a	1	1	1			3
Percent of responses by category	**25%**	**15%**	**25%**	**25%**	**10%**	40

Note: While respondents were asked to rate limiting factors for their museum, some also included factors that they felt were true for all museums.

It is no wonder that museum participants mentioned that the main limiting factor against using technology had to do with money - specifically a *lack of funding* to take on new projects (see Table 19a). The second most common limiting factor against using technology was a *lack of internal technical expertise/experience* needed to design and develop these programs. The third most commonly mentioned limiting factor also had to do with money, and was the *cost of development* (separated from the first factor since the former was described as a general lack of funds to take on any new programs, and the latter referred specifically to the development costs of multimedia programs). In a separate question, the *cost of labor to design and develop* interactive technology-based exhibits was indicated as the largest cost in technology-based exhibit development. Several participants mentioned that they prefer to create less expensive mechanical interactives if they are an appropriate choice for the subject matter. None had performed formal cost comparisons of computer versus non-computer interactives since the inclusion of technology generally changes what is accomplished in the exhibit, causing "like" comparisons to become inexact.

Table 19b

How Would You Rate the Following Potentially Limiting Factors Against Using Technology?

Average rating of factors limiting use of technology in exhibits

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

	Art	Hist	Chld	Sci	Oth	W/Avg*
Funding	2.8	2.9	2	3	1	2.6
Time to develop	2.3	3.5	2	4.3	2	3.0
Quality of products	3.7	2.7	2.5	4	3	3.3
Cost of hardware	2.7	3.5	3	3.7	4	3.3
Lack of Internal Expertise	2.3	3.5	2.8	4	5	3.3
Availability of products	3.3	3.8	3.2	4	3	3.5
Copyright issues	2.8	3.8	4.2	5	2	3.8
Hesitancy by Management	4.3	4.5	4	4.3	4	4.3
Space	3	4.8	4.7	5	5	4.4
Demand by audience	5	4.3	4	5	5	4.6
Type Average	3.2	3.7	3.2	4.2	3.4	

* Weighted Averages are based on 14 participants, except for Quality of products (12); Copyright (13); Demand (12).

Note: Unlike the responses to the previous question, respondents were generally rating these factors based on their own museum experience and not for the museum community overall.

Categories: Funding - same as availability of money to fund interactive technology exhibit development. Time - questions whether the time it takes to design and produce an interactive system is a limiting factor against using technology. Quality of products available - refers to software and hardware used to create interactive multimedia exhibits, and whether they are adequate and reliable tools for design and development. Cost of hardware - self explanatory. Availability of internal technical expertise - questions whether internal staff do not have the technical or interactive multimedia experience to carry out an interactive multimedia exhibit design in-house. Availability of products refers to software and hardware available to create interactive multimedia exhibits, and whether they are adequate tools. Legal issues with copyright - questions whether copyright problems have interfered with development of interactive exhibits. Hesitancy by management - asks whether curators or other decision makers have interfered with the introduction of technology. Space - questions whether lack of floor space is ever a problem in integrating a new technology-based exhibit. Demand by the audience - this was phrased so as to determine whether demand by visitors played a positive, negative or neutral role in introducing technology.

The associations and experts interviewed mentioned the *lack of internal design expertise* in museums as the factor most limiting the use of technology in museum exhibits, followed by a *fear of technological obsolescence* and the *cost to design and develop*. Independent exhibit designers mentioned a *lack of funding* to design the programs as being the most common limiting factor in museums, followed by an *uncertainty of the need for technology* (See Appendix C for tables of the Associations' and Independents Designers' results).

Museum participants were also asked to rate a list of elements that might limit the use of technology in exhibits in order to help judge the relative weights of some of the limiting factors. Ratings were given for each factor on a scale of 1 to 5: 1 being a very limiting factor, 3 being somewhat limiting, and 5 being not at all limiting the use of interactive technology in exhibits. The highest average rating (2.6) showed that *funding* to design and develop interactives was the most common limiting factor (see Table 19b). The time needed to design, build and test interactive exhibits had the second highest average rating as limiting factor (3.0). Availability of *internal technical expertise*, *cost of hardware*, and the *availability of* products that apply to the museum field were each rated "somewhat limiting" on average, at 3.3. 3.3. and 3.5, respectively.

Looking closely at the results shows that the type of museum responding is sometimes an important variable in assessing limiting factors (see Exhibit 5). Art museums rated the *availability of technical expertise* required to design and develop interactive multimedia systems as a much more limiting factor (2.3) than either the history, science or other museums (3.5, 4.0 & 5.0 respectively). This is certainly influenced by the fact that art museums are much less accustomed to designing interactive educational exhibits, plus the fact that the other museums have had more experience with interactivity and technology in exhibits (Nairne, 1992). Art museums also averaged the highest rating for the cost of hardware (2.7) as a limitation, while the zoo (from the "other" category) ranked it the lowest at 4.0 because they were fortunate enough to have had the hardware for their programs donated. Donations had also been made to some of the art, history, and science museums, but they still tended to rate this factor higher knowing that the cost of hardware *can* be a significant factor in an interctive multimedia project.

The zoo and children's museums rated the *funding* needed to design and develop technology-based exhibits as a very limiting factor (1.0 and 2.0 respectively), while it was only rated somewhat limiting by the science museums (3.0), history, and art museums (both 2.8). The lower rating by these three categories of participants seems to contradict their responses to the previous question in which they named "money" as the most limiting factor. Perhaps given a scale, this factor is not as widely important as it appeared to be. The "other" and children's museums also rated the *time* it takes to develop interactive technology-based exhibits as their second most limiting factor based on the choices given. History museums rated the *quality of products available* as the most limiting factor of those presented, but only as a somewhat limiting factor (2.7). This was followed by *funding*, being about as limiting (2.8). Science museums rated most factors fairly low in terms of their limiting the use of technology. Their most limiting rating was given to *funding* (3.0).

Exhibit 5
Ratings for Factors Limiting the Use of Interactive Technology in Exhibits

Museum Type	Most Limiting	2nd Most Limiting	Least Limiting
Art	availability of internal technical expertise; time	cost of hardware	demand by audience
History	quality of products available	funding	space
Children's	funding; time	quality of products available	space
Science	funding	cost of hardware	copyright issues; space; demand by audience
Other	funding	time; copyright issues	availability of internal technical expertise; space; demand by audience
Across Museum Average	funding	time	demand by audience
Associations & Experts*	lack of interactive/ design expertise	rapid technological change; cost to design & develop	n/a
Independent Exhibit Designers*	cost of design/ lack of funding	uncertainty about the need for technology	n/a

* These groups did not quantitatively rate elements as the museums did; association, expert and independent exhibit designer responses in this table refer to the first and second most common responses to the more open-ended previous question, "What are the key factors limiting the use of technology in exhibits?" Their responses are shown here for comparison purposes.

Note: When more than one factor is listed in a category, they received the same average rating or in the case of the non-museum cells they were mentioned by the same number of participants.

Several of the factors that were rated lowest generated some interesting comments. *demand by the audience* was not rated as a limiting factor because most museums stated that the audience does not normally know what they want, they just know when they see it. The museum perception is that interactive multimedia systems can create demand because computers are so compelling. A children's museum put it this way: *The best exhibits go beyond what people are accustomed to...pushing boundaries so that you get a new interpretation.* One history and one children's museum pointed out, however, that because the audience does not always know what they want, this lack of specific demand can be considered a somewhat limiting factor (3.0) in the eyes of management. Regarding *hesitancy by management*, most participants feel it exists because of the cost of implementing a technological solution and

the uncertainty about the need for technology, but several added that management hesitancy has lessened over time. The art museums appeared to have the most conflict in this area:

> *Some curators are really hesitant and others are not. They don't care as much (in general) about the audience; education is new to art museums. They are still elite organizations trying to keep others out of complete information. The administrators really want it to happen (on the other hand), because they see the draw of technology. It's not only an economic benefit that enhances the collection, but an educational benefit that couldn't be had without the technology.*

Other comments centered around the importance of exhibit objectives and making certain that the high-tech solution is really better than a low tech option. Several history and children's museums claimed that too many museums are infatuated with technology, and that this mentality doesn't always produce the best results for the money.

One way of dealing with the issues of high costs and limited experience is to collaborate with other organizations. The Museum Education Consortium and the Interactive Videodisc Science Consortium are two examples of consortiums which were formed to test the use of interactive videodisc in museums and also consolidate skills and common goals (Interview: MEC, 1992). From 1988-1991 the Museum Education Consortium (MEC), a group comprised of the Directors of Education of seven art museums - The Art Institute of Chicago, The Museum of Fine Arts in Boston, The Brooklyn Museum, The Metropolitan Museum of Art, The Museum of Modern Art in New York, The National Gallery of Art, and The Philadelphia Museum of Art - collaborated on *The Museum Visitors Prototype*, a pilot educational videodisc program to be used in a museum environment and also possibly in homes and schools. The Macintosh-based prototype was strictly a research and development effort to test, among other things, the discovery-based learning approach and interface and navigation issues, and to examine if use of the program would encourage seeing or re-examining the real art work in the gallery. The prototype focused on Claude Monet's "Waterlilies," and used a mouse interface to allow the visitor to access images of the painting itself, and information on the artist and the context of his work. The system was very enthusiastically received by visitors, but the MEC had difficulty agreeing on a number of design issues including the target audience, content, and technology. Another problem was that not all MEC members felt that developing interactives was a high priority. The cost of the prototype was approximately $500,000, and reportedly, it is not currently installed as an exhibit in any of these museums. Nonetheless, if additional funding is found full-scale projects are expected to be undertaken by individuals in the MEC with compatible interests. (Interviews: Bank Street College of Education, 1992; MEC, 1992; Wilson, 1992b).

A second example is the Interactive Videodisc Science Consortium (IVSC) formed in 1988, which to date has completed three highly interactive videodiscs at a cost of about $250,000 each, split between 20 IVSC science museum members (Interview: Museum of Science, 1992). The first videodisc titled *Earth Over Time*, is a playful and exciting program in which visitors can learn about plate tectonics and how the movement of the earth affects

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