Hands-On, Hands-Off: the personal, social and physical context of interactives in museums

Grahame Ramsay, University of Western Sydney, Austrailia

Abstract

"Interactives" have become an integral part of the exhibits of many museums. The term "interactives" has been used as a shorthand description for interactive multi-media displays based around a computer and operated by an individual. In the Powerhouse Museum, Australia's largest museum, the term's usage has been expanded to include manually controlled exhibits that don't use a computer at all. These "interactives" share the common characteristic that they require a person to manipulate them. This research relies on the proposition (Dierking and Falk, 1992) that each museum visitor "constructs" their own museum experience. This has been called the "Interactive Experience Model" and has been used as the key framework for this research. This model postulates that the museum visitor's experience is a combination of three contexts: the personal, the social and the physical. A sample of computer based " interactives" and non-computer based "interactives" were chosen for observation. Four hundred and seventy-eight people were observed using interactives. Similarities and differences in usage were noted and the usage of computer based and non-computer " interactives" compared. The research also investigated the history, classification, instructional design and purpose of "interactives" as part of exhibitions within the Powerhouse museum. The study considered trends in interactive exhibit design, key success factors for "interactives" and key limiting factors on the use of "interactives" by museum visitors.

Introduction

An icon, which is a stylized drawing of three hands, appears on many exhibitions within the Powerhouse Museum and signals to visitors that this is a "hands-on" or "interactive" exhibit and gives permission for the visitor to touch it. In the drawing that is the icon, one hand is pressing a button, another hand is turning a handle and the third hand is reaching inside the box. The icon also demonstrates that there are many possible ways that someone can have a "hands-on" experience with an exhibit. In practice, the label was applied to exhibits ranging from playground style equipment that children explored to interactive multi-media computer-based exhibits that required advanced detective skills.

This philosophy of allowing people to touch exhibits contrasts with the hands-off approach of some museums. Common signs in some museums say DO NOT TOUCH, KEEP OFF, ELECTRONIC SURVEILLANCE. These signs are reinforced by the physical presence of guards who police a "no touching "policy (Well, 1995, Bennett, 1995). This "hands-off" approach has led to museums being described as "mausoleums" (Whitcomb, 1997). By contrast, Steuert (1993) has described the use of interactive media within museums as inclusive with the museum users gaining an understanding through handling and experiencing objects.

To understand and define " interactives" within the museum requires an understanding of the history and development of science and technology museums, and the role of interactive "media" within the museum context.

A Statement of the Problem

"Interactives" are an evolving technology that include developments in hardware, software and even the conceptual language now operating on the World Wide Web and in games produced by Nintendo. The "interactives" at the Powerhouse Museum represent a range of devices over time of interactive multi-media (IMM). There is a style IMM using early Amiga computers that were the first examples of IMM in an Australian Museum and date back to 1987. Others, incorporate the latest touch screen technology. This research sought to discover if there was any resistance among museum visitors to computer technology which required them to adopt procedures that would be unfamiliar to many young computer users. At a simple practical level the mixture of old and new technologies required the museum to label computer screens with signs "This is NOT a touch screen". There were also examples of users being confused by "red lettering" which they assumed to be a hypertext link and clicked on only to find it was just red lettering (Ramsay, 1998).

However contemporary in approach, technology is changing so fast that museums are unlikely to have the "latest" technology. Museums, therefore need to create novel exhibits that incorporate the past, present and future of IMM.

Classification of IMM is quite difficult if we are to consider technologies that span 10 years. Some of the possible classifications include considering physical features (computer or software used), computer-based or non-computer based, target audience, navigation methods and sophistication.

Interactives are popular with visitors and attractive to curators (Ramsay, 1998) "Interactives" have been a defining characteristic of the Powerhouse museum, and the Powerhouse is recognized nationally as a leader in the use of "interactives" in museums (Chambers, 1992). There seem, however, to be little empirical research to explain the popularity of "interactives" within the Powerhouse Museum. While the term "interactive" can be restricted to computer based interactive multi-media, it has a much wider meaning in the Powerhouse museum and has been used to describe non- computer based science experiments. The use of umbrella terms term like "hands-on" and "interactive" to describe vastly different kinds of exhibition tools, has produced a blurring of important differences between these tools. To say that "interactives" are popular is like saying "videos" are popular without being precise enough to generate a sensible classification. There are also popular and unpopular videos as there are popular and unpopular "interactives". Part of the task of this research is to compare some of the variety of "things" that have been described as "interactives". Inappropriate expectations have been produced by grouping computer based multi-media with non-computer based "hands-on" tools and assuming they share identical potential and produce similar outcomes. The "interactive" medium should not alone be considered the message. Even, if each individual "constructs" their own museum experience (Dierking & Falk, 1992) it is worth investigating the similarities and differences in museum visitors use of particular interactives.

Museum exhibitions at the Powerhouse museum have evolved from displays of artifacts with appropriate written labels to complex exhibition environments with design of space, lighting, backdrop, artifacts, working models, live performers, video, and interactive multi-media (Chambers, 1992).

This study looked in detail at one part of museum exhibitions: the "interactives". These are either a computer screen mounted into a booth with a chair for one person to sit and interact. Touch screen or mouse and keyboard controls were used by the museum visitor to interact and there were frequently a number of possible routes that the user could navigate through (Caulton, 1998). Alternatively the "interactive" may be a range of objects that need to be manipulated by the user to produce and effect (Stephenson, 1991). An example of such an "interactive" was a wheel mounted on an axle that can be rotated. From this "interactive" the user can infer certain principles of physics (Thomas, 1995). The use of terms like "hands-on" and "interactivity" carry important philosophical and learning implications within the recent history of museums (Pearson, 1994). They have particular significance within the context of Science and Technology museums with the term "hands-on" and "interactives" being used for discovery learning activities that emerged from developments such as the Exploratorium in San Francisco (Oppenheimer, 1986). These activities have used common objects and relied on active involvement of many senses by users. More recently "hands on interactives" has come to be used to describe computer based interactive multimedia frequently delivered by touch screen technologies (Friedman, 1997). Mechanical displays that involve the user pressing a button to start it, could not be considered "interactive" (Jones-Garmil, 1997; Quinn, 1994).

This research aims to add to the understanding of the role of "interactives" within the Powerhouse museum. It seeks to provide greater depth of analysis of the interactives and the relationship to their users during a museum visit.

Interactives and Interactivity

This research sought to identify and analyze the range of tools that have been broadly categorized as: "interactives" within the Powerhouse museum. It sought to trace the origins of the terms and their usage within a museum context. Interactives represent the convergence of two separate traditions within the science and technology museum.

The first is tradition derived from San Francisco's "Exploratorium" which emphasizes active participation by users in hands on experiences. Users do experiments and infer scientific principles from first hand experience (Danilov, 1982). The museum was started by a maverick scientist, Oppenheimer, who challenged the orthodoxy of museums as places to look but not touch and replaced that with a "hands-on" experience (Oppenheimer, 1986).

The second tradition is derived from the British Science museum and emphasizes working models of machines (Butler, 1992). Users have been able to set machines in motion by pressing buttons. This tradition frequently employs cut-away sections of machines that allow users to see processes that would have been hidden in the past. Interactives have the potential to demonstrate processes and enable the user to see from new perspective's (Pearce, 1992).

Interactives in an Exhibition Context

Traditional forms of museum displays are either passive (glass showcases) or active (working models of machines). Both methods can be described as "hands-off". "Hands-on" and interactive exhibits, by contrast, encourage visitors to touch and interact with objects including computers. Interactives set problems for users to solve, mysteries to unravel or a knowledge/test sequence that encourages learning about a topic.

Interactives are the most recent response by the Powerhouse museum to contemporary technology which might be used in museum exhibition. Their perceived importance is indicated by the Powerhouse establishing a department to produce interactive multimedia (La Fontaine, 1994). The current organizational chart (December 1997) lists 11 staff in the Interactives Department of the museum, including a supervisor, electrical engineer, systems officer, multimedia programmer and graphic designer. Interactives are included in most exhibitions as the chart of the exhibitions indicated.

On the demand side, surveys indicate that interactives are memorable and popular with museum users (Purser, 1993). The use of umbrella terms term like "hands-on" and "interactive" to describe vastly different kinds of exhibition tools, has produced a blurring of important differences between these tools. The origins of this stem from the convergence of different technologies and traditions.

Previous usage of the term "hands-on" have described activities that involved many of the senses in discovery (Thomas 1994) and experiential learning (Kolb, 1984). Museum visitors employ many learning styles when they engage with exhibitions (Kolb, 1986). Inappropriate expectations have been produced by grouping computer based multi-media with non-computer based "hands-on" tools and assuming they share identical potential and produce similar outcomes.

The appropriation of the term to describe computer based interactives may confuse its meaning but it may also indicate the evolution of the term "hands-on" to describe the underlying intention of the computer based interactive.

Their influence is now so pervasive that one Powerhouse Museum exhibition called CYBERZONE was entirely based on interactives with no artifacts. "Interactives" can be seen as part of a range of tools for exhibitions which include photographs, drawings, labels, working models, videos. Just another tool in the curators' craft (Jones-Garmil 1997).

This research argues that interactives have both implicit and explicit functions that place them in a different position in relation to the museum visitor than other components of an exhibition. They provide unique experiences, they carry potential educational function, they use a technology that brings the museum into a contemporary framework, they provide different experiences from books, information labels and photographs. They can allow for individual navigation through unique pathways. They can allow for group interaction. They are inherently attractive to school children. They provide a simulated "hands-on experience" and are "new tools for new minds" (Sewell, 1990).

The reason for the increase in both mechanical and electronic interactives have to do with the deep-seated belief that interactivity provides a more attractive, engaging and educational experiences (Caulton, 1998).

The Powerhouse Museum

The Powerhouse Museum is one of several museums which come under the umbrella of the Museum of Applied Arts and Sciences. Although the Museum has been in various locations for a century, the present Powerhouse Museum has only been in its present location since 1987.

The mission statement of the Powerhouse Museum is that it will be

> a dynamic, innovative and enjoyable museum which promotes awareness and understanding of the past, present and future of Australian society through research, scholarship and the acquisition, conservation and integrated presentation of material in the fields of science, technology, industry, design, decorative arts and social history (MAAS Annual Report 1996/1997, 1).

Key Learning Area	Exhibition Title	Type Of Media
Science	Pills and potions	IMM/ Artifacts
	The cut above, surgeons, science and status	IMM/ Artifacts
	Experimentations	IMM/Hands-on/ Artifacts
	Chemical attractions	IMM/Hands-on/ Artifacts
Technology	Locomotive No1	Artifact
	Boulton and Watt engine	Working artifact
	Big Wheels little wheels	IMM/ Artifacts
	Kids up and down	Hands-on
	The steam revolution	Working Artifacts IMM
	Information technology center	IMM
	Soundhouse	Digital music
	Space: beyond this world	IMM / Artifacts
	CYBERZONE	IMM/ Hands-on
	Flying high, down under	Artifacts
	KIDS music	Hands-on
	KIDS on screen	IMM
		IMM
Industry	Simply the best	IMM/ Artifacts
	Brewing and pubs	IMM/ Artifacts
Design	Success and Innovation	Cheryl's big break(IMM)/ Artifacts
		Teapots(IMM)/ Artifacts
	Style	Artifacts /Videos
		Artifacts/ Videos
	Fashion of the year	
	Student Fashion Awards	
Decorative Arts	International Lace for Fashion Award	Artifacts/ Photographs
Social history	The lions of Retreat Street: a Chinese temple in Sydney	Artifacts/ Photographs
	The Kings Cinema (1930's cinema)	Film projection
	KIDS at home	Hands-on
	Never done, woman's work in the home	Artifacts
	Stepping out: three centuries of shoes	Artifacts/ IMM
	Ngaramang Bayumi: indigenous Australian music and dance	Videos/ Artifacts
	50,000 days: the Herald's Sydney since 1831	IMM/ Videos
	Musical instruments	Artifacts
	Evolution and revolution Chinese dress 1700s to now	Artifacts/ Videos

Table one

This broad mission indicates that the museum goes beyond the boundaries of many other science museums. A list of the exhibitions in place at the time of this research indicates the breath of that vision. A large number of exhibitions also included computer based interactive multi-media (IMM) or other hands-on exhibits. In April, 1998, the major exhibitions can be grouped into the following categories. Where there are both IMM and Hands on interactives present they are both listed.

The wide rage of IMM and hands-on covering many curatorial areas indicates the central role of interactives. The emphasis on social history as well as science and technology indicates the eclectic nature of the Powerhouse Museum.

A previous cultural studies analysis of the Powerhouse Museum (Mander-Jones, 1989) concluded that the " interactives" enhance the museum's mythical quality. One could use such an analytical approach to consider some of the possible meanings produced within interactives. It would be interesting to consider whether the interactives "speak with the same voice" as the rest of the exhibition and/or tell the same message to different audiences. It is also worth hypothesizing on the specific genre characteristics of " interactives". This is a somewhat peripheral to the present research and will only be mentioned where relevant.

There is also a tradition of visitor studies and a very active evaluation section of the Powerhouse museum. These studies include formative (Savage, 1995) and summative (Cronin, 1997) but are commercial in confidence and so were not accessible for the purpose of this research. There has also been research by curatorial staff (Webber, 1996) on areas relating to their specialization. This is very specific to particular artifacts (in this case Victorian

furniture) and so is of limited application to this study.

Towards a Definition of Interactives

Interactives can all be described under the following definition:

> A hands on or interactive museum exhibit has clear educational objectives which encourage individuals or groups of people working together to understand real objects or real phenomena through physical exploration which involves choice and initiative (Caulton, 1998 p2).

"Interactive" implies that there is some mental interaction and control with the user (Kennedy, 1994, p.2). The term "interactive" has been appropriated to mean interactive multi-media and even computer games (Schwier & Misanchuk, 1993). However this narrow classification is rejected for this study. An exhibit that simply involves pushing a button to get it started is considered outside this classification as it is "reactive" rather than "interactive" (Swift, 1997, p.23).

In this study the broad classification "interactive" is then divided into "Hands-on" and "IMM" groups. "Hands-on" interactives are exhibits that the visitors physically interact with, manipulating objects in some way (Dean, 1994). Such exhibits, within this study, range from a plastic balloon balanced in an air-stream to a bike that users pedal to generate electricity. IMM interactives are interactive multi-media operating on a computer which are navigated by touch screen, pushing buttons or using a keyboard.

If we consider Caution's (1998) definition, all IMM is not automatically included within it. IMM programs do not always have clear educational objectives nor do they always aim to develop understanding for the user. A computer game of a Grand Prix car race may involve choice and initiative but it may not meet other criteria. If multi- media is defined as any combination of two or more media used to present information, then many museums currently present visitors with multimedia experiences (Bearman, 1993).

The interactives in the Powerhouse museum range from touch screens with complex navigation styles to much simpler "Yes/No" choice buttons. Interaction is a function of what the software program will allow It is also a function of the possible navigation choices for users (Metros, 1994).

For this research Schwier's (1993) definition of Interactive Multimedia instruction (IMM) has been chosen:

> Interactive multimedia instruction is an instructional program which includes a variety of integrated sources in the instruction with a computer at the heart of the system. The program is intentionally designed in segments, and viewer responses to structured opportunities (e.g. menus, problems, simulated crises, questions, virtual environments) influence the size, content, and shape of the program (Schwier, 1993:6).

There are important capacities of the medium. Laurillard (1995) observes there is a tension between the technological pull of changing capacity of the medium and the pedagogical pull to keep it on track educationally. While an interactive can now hold enormous quantities of data there still needs to be some organizing principles for the user to access that data.

A computer-based learning environment is one where learners interact with information in a self regulated environment (Reiber, 1996). Underlying the move to provide broader learning experiences through multiple media, is a recognition of the importance of interactivity in helping to gain new understanding. By immersing the visitor in exhibit experiences and activities, giving them greater control and more options for exploration, visitors discover that fun can also mean learning. Interactivity, in all of its forms, is increasingly seen as the true key to enhancing learning for the museum visitor (Hooper-Greenhill, 1993).

Certain themes connect interactives and learning. Interactives are seen as offering an attractive and accessible way for students to gain an understanding and appreciation of science (Anderson 1997).

There is support for the educational role of a museum which is seen as central to a science museum because of the perception of science as esoteric, hard and not well taught in schools. (Ramey-Gassert, 1994). Museums have a role, then in promoting and educating people about science (Hooper-Greenhill, 1993, 1994). Interactives are perceived as an ideal tool for that purpose (Bearman, 1991). Interactives are also the cornerstone of bringing the museum collection out of buildings and to the public through digital means such as the internet, CD-Roms or electronic kiosks in public spaces (Bearman, 1995a).

Mode of Inquiry

Participants
Four hundred and seventy eight visitors to the museum were observed. The observations occurred over a three month period and included weekends, weekdays and school holidays. This allowed for research of quite distinct users including school excursion groups, family groups, individuals, adults and tourists. Each of the interactives were observed in two hour blocks and user's behavior noted during that time recorded.

Data Collection Procedures
Field notes of each subject were made by the one researcher (the author of this paper). Variables to be noted include age group, gender, position (sitting standing, kneeling) whether the subjects completed the narrative. Whether they involve other people. Specific observational schedules were avoided to allow for more interesting data unconstrained by preconceptions of the researcher.

Procedure

1. The data was collected by the researcher sitting in a unobtrusive position where he could see the users. Fill out field notes

2. Data transferred to computer

3. Data analysis

Coding categories included age-group and gender of users/group or individual/family or school group. Time spent at interactive. User behavior in dealing with the interactive.

Ethical considerations
All museum visitors were made aware of the research by signs at the entrance to the museum. Protocols and procedures were checked and approved by Carol Smith Evaluation Coordinator, Powerhouse Museum. The researcher was identified by a photo identification as a "staff" member

Title	Main exhibit	Observation point
Air balloon	Experimentation	Standing opposite
Kids on Screen	KIDS Under 8	Chair in empty booth
Pedal power	Experimentation	Chair opposite
Resolution	CYBERZONE	Chair opposite
Turbo Courier	CYBERZONE	Standing adjacent

Table Two. Interactives for Observation: Hands-On Interactives

Title	Main exhibit	Observation point
Cheryl's big break	Design and innovation	Stand to the left of Ear display
The energy game	The steam revolution	Chair in empty booth
Furnish with style	Style	Chair in opposite corner
Multimedia	CYBERZONE	In corner
Being digital	CYBERZONE	Standing opposite
Guess the face	CYBERZONE	Standing opposite

Table Three. Interactives for Observation: IMM Interactives

of the Powerhouse and was occasionally asked directions, which he gave. Visitors are accustomed to people taking notes and or sitting watching as this is the common method for museum visitor studies and security. In places like CYBERZONE there were always many people standing around watching because there were more people than there were interactives. I could not detect any evidence that my presence affected the behavior of the users of the interactives, and at no time did anyone ask what the researcher was doing or indicate evidence of being observed. No audio tape or videotape was used apart from the photographs included in this this. These were taken of the researcher's children using the exhibits at non-research times. His children were not included in the research sample and no research was conducted during the photography. There is also one photograph of a museum staff member using the bicycle interactive.

Conclusion

Each of the interactives displayed unique characteristics. As the Interactive Experience Model proposed, the behavior of individuals with interactives was an intersection of those three different contexts. A problem in one context could impact on the usability altogether (e.g. the seat height and monitor position of the Energy game).Observation in all three contexts yielded a rich picture of the experience of users with interactives. The three contexts, personal social and physical were a useful tool for analysis. Factors in all three contexts impinged on the behavior of users in all 11 interactives.

Different interactives appealed to different ages. The Kids interactives originally designed for Under 8's appealed to children from 2 -18. Adults avoided some (Turbo Courier), joined their children in others (Cheryl's Big Break) and took over completely in others (Furnish with style). Some interactives were more successful in retaining the user. The vast majority of subjects observed completed Cheryl's Big Break, but many users gave up on The Energy Game.

There were some wide variations in the control by parents of their children. Some herded children and supervised their interaction to the extent of actually pressing buttons for them, other parents let the children find their own path but stayed nearby. Another parental group used the interactives as an electronic baby sitter while they went off to look at other parts of the museum.

In the personal context "control" was the most obvious difference between each of the interactives. The lack of control in the "Energy Game" produced great frustration while the many choices and pathways for "Cheryl's Big Break" led to more satisfied users who completed the sequence. There was evidence of optimal experiences for users of the, Kids on Screen, Resolution, Turbo Courier, Cheryl's Big Break, Crack the Code, Style and the Multi Media Booth. The other interactives had features that distracted from optimal experience and produced frustration, early termination and some confusion.

In the social context there was more interaction between people in the hands-on interactives than in the IMM ones. There was also more supervision by teachers of the hand-on interactives and some teachers discouraged students from using the hands-on interactives. Teachers made derogatory comments like "Don't waste your time playing". "Come over here and read this". Such comments were a minority response and most teachers adopted either a passive role or an active explainer role.

The interactives where most social interaction and co-operation occurred were "Kids on Screen", "Pedal Power" and the "Multi Media Booth."

In the physical context, ergonomic factors made some interactives more useable than others. There were problems at specific points that consistently affected users (e.g. the difficulty of taking photographs in the Multi-Media Booth). The most user friendly interactives from an ergonomic viewpoint were" Cheryl's Big Break', "Kids on Screen", "Resolution", and "Turbo Courier."

Comparing the hands-on and IMM interactives as a "class" there appeared to be generally more social interaction with the hands-on interactives. People involved more of their senses and were more absorbed in the hands-on interactives such as "Turbo Courier" and "Pedal Power."

It was apparent that some of the interactives were more successful than others and produced more positive responses from the users. In the IMM interactives, "the Energy Game" had the most negative responses in more categories than any other interactive. It had navigation problems, confusing feedback, negative reinforcement and denied users control at key points. Its layout didn't allow for more than one person to work together and the recessed screen forced adults into contortions when they tried to view it. By comparison, "Cheryl's Big Break" produced more positive responses with an engrossing and imaginative task, appropriate control, social possibilities and excellent design of access and the interface. In the hands-on interactives both "Turbo Courier" and "Pedal Power" produced

the most consistent involvement. The "Air Ball" was more problematic in all categories.

The research indicated a high degree of congruence in the response of individuals and groups to particular interactives. The design faults/limitations of particular interactives had an effect on usage across all ages and gender. A major problem in one area of the physical, social and personal context spilled over in the reaction of users in all three contexts. The research also indicated that computers cannot completely replace the social potential of non-computer interactives. While the designers of IMM may think they hold copyright on the word "interactive", it remains a robust and evolving concept within museums for which computers are but one expression.

References

Anderson, D. (1997). *A common wealth: museums and learning in United Kingdom.* London: Department of National Heritage.

Bearman, D. (Ed). (1991)., *Proceedings of an International Conference on Hypermedia and Interactivity in Museums* (pp. 63–77). Pittsburgh: Archives & Museum Informatics.

Bearman, D. (Ed). (1995a). *Hands on hypermedia and interactivity in museums.* Pittsburgh: Archives & Museum Informatics.

Bearman, D. (Ed). (1995b). *Multimedia and computing in museums* Pittsburgh: Archives & Museum Informatics.

Bearman, D. & Trant, J. (Eds). (1997). *Museum interactive multimedia: cultural heritage system design and interfaces* Pittsburgh: Archives & Museum Informatics.

Butler, S. (1992). *Science and technology museums.* Leicester: Leicester University Press.

Caulton, T. (1998). *Hands on exhibitions: managing interactive museums and science centers* London: Routledge.

Chambers, W. (1992). Australia's Museum Powerhouse. *Technology and Culture* 33, 3, (pp. 548–552).

Csikszentmihalyi, M. (1995). Intrinsic motivation in museums: Why does no one want to learn In Dierking, L. & Falk, J. *Public institutions for personal learning: establishing a research agenda* Washington, D.C: American Association of Museums.

Diamond, J. (1994). The exploratorium's explainer program: the long term impacts on teaching science to the public *Science Education* 71, 5, (pp. 643-56).

Diamond, J. (1996). Playing and learning *ASTC Newsletter* July Washington: Association of Science Technology Centers Incorporated.

Dierking, L. & Falk, J. (1992). *The museum experience* Washington, D.C: Whalesback Books

Dierking, L. & Falk, J. (1995). *Public institutions for personal learning: establishing a research agenda* Washington, D.C American Association of Museums.

Harvey, M. (1998). The influence of museum exhibit design on immersion and psychological flow. *Environment and Behavior* 30, 5, (pp. 601-627).

Hedberg, J., Harper, B., & Brown, C. (1993). Reducing cognitive load in multimedia navigation *Australian Journal of Educational Technology* 9, 2, (pp. 157-181).

Herrmann (1995). Museum memory. In Dierking, L. & Falk, J. *Public institutions for personal learning: establishing a research agenda* Washington, D.C American Association of Museums (pp. 53-60).

Hooper-Greenhill, E. (1993). *Museums and the shaping of knowledge* London: Routledge

Hooper-Greenhill, E. (Ed). (1994). *The educational role of the museum.* London: Routledge

Hoffos, S. (1992). *Multimedia and interactive display in museums, exhibitions and libraries* London: British Library.

Jonassen, D. H. (1994). Thinking technology, toward a constructivist design model *Educational Technology*, April (pp. 34-37).

Jones-Garmil, Kathy. (1997). ed., Laying the foundation: Three Decades of Computer Technology in the Musueum in *The wired museum.* Washington DC: American Association of Museums, (pp. 35-62).

Kolb, D. & Smith, D. (1986). *User's guide for the learning style inventory. A manual for teachers and trainers* Boston: Mac Ber.

Kolb, D. (1984). *Experiential learning: experience as the source of learning and development.* Englewood Cliffs: Prentice-Hall.

La Fontaine, K. (1994). *Creating computer interactive exhibits* Sydney: Museum of Applied Arts and Sciences.

Laurillard, D. (1993). *Rethinking University Teaching: A Framework for the Effective Use of Educational Technology.* London, UK: Routledge.

Laurillard, D (1995). Multimedia and the changing experience of the learner *British Journal of educational technology,* 26, 3, (pp. 179-189).

Lucas, L. (1992). Interactivity: What is it and how to use it? *Journal of Educational Multimedia and Hypermedia* 1, (pp. 7-10).

Metros, S. (1994). Investigating Lake Iluka: Graphic Design for the Interface, Interactions: New *Visions of Human-Computer Interaction* New York City: ACM, Inc. 1, 3, (pp. 26-40).

Nash, C. (1992). "Interactive media in museums: looking backwards, forwards and sideways". *Museum Management and Curatorship* 11, (pp. 171-184).

Oppenheimer, F. (1986). *Exhibit concept and design in Working Prototypes* San Francisco: The Exploratorium. (pp. 5-15).

Quin, M. (1994). Aims and strengths and weaknesses of the European science center movement. In Miles, R. and Zavala (Eds). *Towards the museum of the future,* London: Routledge, (pp. 39-55).

Ramey-Gassert, L. & Walberg, H. (1994). Re-examining connections: museums as science learning environments. *Science Education,* 78, 4, (pp. 345-364).

Ramsay G. (1998). *Interview with Carol Scott,* Powerhouse Museum Evaluation co-ordinator Grahame Ramsay (April).

Ramsay, G. (1999). Investigating interactives at the Powerhouse Museum: personal, social and physical context. *Ed Tech 98 Proceedings* Perth: Murdoch University.

Roschelle, J. (1995). Learning in interactive environments: prior knowledge and new experience. In Dierking, L. & Falk, J. *Public institutions for personal learning: establishing a research agenda* Washington, D.C: American Association of Museums.

Savage, G. (1995). *Front-end evaluation of proposed exhibition to attract families with children under eight years* North Sydney: Environmetics.

Schwier, R.A. & Misanchuk, E.R. (1993). *Interactive multimedia instruction.* Englewood Cliffs: Educational Technology Publications.

Steuert, P (1993). *Opening the museum: history and strategies towards a more inclusive institution,* Boston: The Children's' Museum.

Swift, F. (1997). "Time to go interactive" *Museum Practice* - (p. 31).

Thomas, G. (1994). The age of interaction *Museums Journal,* May, (pp. 33–36).

Thomas, G. & Caulton, T. (1995). Objects and interactivity: a conflict or a collaboration *International Journal of heritage studies, 1, 3,* (pp. 143-155).

Thomas, G. & Caulton, T. (1996). Communication strategies in interactive spaces. In Pearce, S. (ed). *New research in museum studies:* London Athlone Press, (pp. 107-22).

Tomlin, N. (1990). Interactive science centers and the national curriculum. *Journal of education in museums, 11,* (pp. 12–15).

Tufte, E. (1990). *Envisioning Information.* Cheshire, CT: Graphics Press.

Veenema, S. & Gardner, H. (1996). *Multimedia and multiple intelligences. The* American Prospect, 29, (pp. 69–75).

Veller, Z. (1997). New opportunities for visitor collaboration. In Jennings, G. (Ed). (1997). Digital media in museums: preparing for the post-hype era", *Journal of Museum Education* Washington, D.C., Museum Education Roundtable, 22, 1, (pp. 13–16).

Wallace, M. (1995). "Changing media, changing messages" In Hooper-Greenhill (Ed). *Museum, Media, Message* London, Routledge: (pp. 107–123).

Waterworth, J. A. (1992). *Multimedia Interaction with Computers: Human Factors Issues. Chichester,* Sussex: Ellis Horwood Ltd.

Well, S. (1995). *A cabinet of curiosities: inquiries into museums and their prospects*. Washington: Smithsonian Institution Press.

Wild, M. (1995). Perspectives on the place of educational theory in multimedia In Hedberg, J. G., Steele, J.& McNamara, S.(Eds). *Learning technologies: Prospects and Pathways*. Canberra: AJET Publications.

Will, L. (1994). Museums as information centers. *Museum International* 46(1).: (pp. 20–25).

Williams, N., & Hartley, P. (Eds.). (1990). *Technology in Human Communication*. London: Pinter.

Willow, D. (1997). "Digital beginnings", In Jennings, G. (Ed). "Digital media in museums: preparing for the post-hype era". *Journal of Museum Education* Washington, D.C.: Museum Education Roundtable, 22, 1.

Witcomb, A. (1997). *The end of the mausoleum: museums in the age of electronic communication in Museums and the Web*. Pittsburgh, Archives & Museum Informatics, (pp. 143-150).

Wood, R. (1990). Museum learning: a family focus *Journal of Education in Museums*, 11, (pp. 20–23).