the importance of a museum's educational purpose has only grown (Booth et al. 1982; Chapin & Klein, 1992; Excellence & Equity, 1992; Gable, 1992). The latest modification to the AAM definition now describes museums as "institutions of public service and education, a term that includes exploration, study, observation, critical thinking, contemplation and dialogue" (Excellence & Equity, 1992, p. 6). This new definition clearly aims to promote the informal educational role of museums by encouraging activities that induce individual responses to exhibits. More specifically, it focuses on non-traditional methods of teaching, encouraging learning in an open, exploratory, user-paced environment. While the official definition may merely represent another nobly worded goal not necessarily supported by actual museum activities, recent research and results from the interviews conducted for this study reflect this new AAM definition.

The History of Interactive Multimedia in Museums

Among the many similarities across the categories of museums is the fact that all museums present visitors with multimedia experiences (Alsford, & Granger, 1987; Bearman, 1993). Multimedia refers to any combination of two or more media used to present information, such as a slide show accompanied by narration or an artifact displayed near descriptive signage. Museums are multimedia experiences since the visitor to any museum is typically exposed to a number of media, such as paintings, historical artifacts, live animals, or informational labels, each of which represents a different communication medium. Museums are also interactive in that a visitor need not experience the exhibits in a linear manner - visitors can move at will from one exhibition room to the next, making use of whatever available media (artifact, brochure, label, audio tape, guide, etc.) they choose to help them explore the museum. In science and children's museums this notion of offering interactive multimedia experiences has a slightly different meaning; visitors of these museums are encouraged and expected to use their senses of sight, hearing, and touch to *physically* interact with the exhibits. Interactive multimedia technologies are yet another element of the multimedia experience that can be found in museums. These refer to the computer-generation technologies that incorporate multiple media, such as text, sound, video, or graphics, into an integrated computer system, which then serves as an exhibit that can inform the visitor on a relevant museum topic using the most appropriate communications media. Throughout this report the phrase interactive multimedia will generally refer to this more recent usage of the term multimedia as opposed to the non-technological definitions.

The use of interactivity and technology in museums has been influenced by the differing objectives and educational philosophies customary to different types of museums. Consider each of the five museum categories examined in this study in turn: art; history; science and technology; children's; and botanical gardens, arboretums, zoos, and aquariums.

Art museums contain collections of paintings, sculptures, pottery, and other noteworthy artistic artifacts. The educational goal of these museums is typically to "train the taste and aesthetic receptiveness of the visitor" (Zetterberg, 1968, p. 47). The interpretation of art,

and therefore, the learning that takes place, is highly dependent on the visitor's background and/or the addition of contextual information provided by the museum curator (Booth et al., 1982). It is at least partly due to this dependency on the curator to provide an art or art history background that these museums have had the greatest difficulty in letting go of the past elitist stance of museums (Hudson, 1977). Other reasons for this historical posture relate back to the power associated with the creation and possession of art, and the intention of the artist him or herself. One museum interviewee described artists as generally hoping to *do* something to their viewers, they want to affect them, not necessarily educate them (Interview: The Experimental Gallery, 1992).

Another characteristic of art museums is that they still tend to be conceived by many visitors as intimidating. Kenneth Hudson (1987) describes museums as having "remarkable powers of making the uneducated feel inferior" (p. 8). Hudson's description referred to all types of museums, but other authors and interview participants agree that this feeling is particularly obvious and persistent in art museums (Chapin & Klein, 1992; Zetterberg, 1968; Interviews: The Experimental Gallery, 1992; Museum Education Consortium, 1992). This feeling of inferiority is evident upon walking into most art museums, in which there is often a severe or detached and very defined relationship created by the size of the halls, the heightened or protected placement of art, and the silence that resonates. For visitors with art backgrounds, this peaceful and solemn atmosphere is precisely the environment they seek in which to contemplate the artwork. For others, however, the meaning and significance of the work is hidden without the docent, label, or other supplementary informational display (Maton-Howarth, 1990; Miles et al., 1982).

Art museum curators attempt to fill the gap in information common to this environment by providing ideal conditions for viewing and contemplating the art, and by offering lectures, brochures, and guided tours. These approaches supplement the exhibitions with traditional educational media, maintaining the traditional focus of the exhibits as works of art to be admired. Although there are differing philosophies, art museums have historically focused on collecting and preserving for the purpose of allowing visitors to experience beauty in art, rather than on specifically teaching about art or art history (Alexander, E., 1979). However, in response to visitor requests for more information and in order to capture a wider audience, some art museums are using computer-based technologies in their exhibit halls. The capabilities of computers and related technologies make a greater portion of the collection available to visitors and also provide user-driven access to much more information than can be feasibly included in signage or lectures.

History museums were created to gather information about cultures, societies, and nature, so that visitors could better understand the past and present. Natural history museums provide information on numerous topics including fossils, rocks and minerals, extinct animals, and the solar system. Other types of history museums focus on the objects of past societies, such as portraits of scholars or poets, historical documents, or coins and medals (Alexander, E., 1979). Because they hold artifacts taken from the world around us, history museum exhibits have more of an obviously relevant link to visitors' lives than do the exhibits of art museums. Labels, tours, and brochures are often used to supplement the infor-

mation in the artifact or specimen and increase its educational value, and more and more, interactive computer-based exhibits are being used for supplementary educational purposes.

Science and technology museums and centers originally started out as places to view the history of man through his technological inventions, and have expanded to include exhibits on all physical and natural sciences (Alexander, E., 1979). Secondary research and the interviews conducted for this study indicate that many science and technology museums share the pedagogical theory that *doing* an activity is more educational than reading or hearing about it, not to mention that doing is more fun (Parr, 1992). This emphasis on "doing" is supported by science museum and science education studies which have shown that the difference between watching and performing is so significant that it can turn a bored student into an interested one. This widespread philosophy indicates that science museums are clearly interested in providing activities that encourage learning to take place (Booth et al., 1982; Harte, 1989; Wertheim, 1992; Wilson, 1987). This is at least one reason why the National Science Foundation (NSF) has given $60 million per year in grants to science museums to develop teacher training programs (Chenoweth, 1990).

At least partly due to their interactive philosophy, the science and technology museums and centers are said to have pushed the introduction of computers and related technologies into the museum environment, not only as artifacts, but as interactive presentation tools (Cassedy, 1992; Interview: Tech 2000, 1992). The centers tend not to have many or any artifacts, focusing on highly interactive exploratory exhibits and activities. They also tend to be noisy with a large young audience, often attributed to the substantial number of visitors that are school children on field trips. A large portion of the audience is the casual visitor who is attracted to the fun and interesting activities and the "aha!" experiences commonly associated with these museums and centers (Parr, 1992).

Children's museums are often very similar in purpose and method to the science museums, as they tend to focus on informing the visitors about science and present information using very interactive, hands-on, discovery-based learning methods that include but are not limited to interactive technologies (Feber, 1987; Harte, 1989; Maes, 1992; Ogintz, 1992a; Szilagyi, 1991). These museums choose entertaining and educational topics that would appeal to children and families, such as allowing visitors to climb inside an actual police car or ambulance, or showing them how ocean waves are formed by rocking clear containers full of liquids, and many of these museums are using computer technology as well. They also tend to be very noisy environments, which is understandable given the target audience, and they generally have limited numbers of artifacts.

Botanical gardens, arboretums, zoos, and aquariums are most similar in objectives and purpose to history museums, with the key difference being that their objects are living. Historically, this category of institutions has highlighted the leisure and entertainment qualities of their domain, but in the last ten years they have become much more educationally-minded by stepping beyond the label into guided tours, informational audio tapes, classes, and computer-based exhibits to supplement the visitor's enjoyment of the animals (Alexander, E., 1979; Interview: The St. Louis Zoo, 1992).

All kinds of museums have been influenced by recent social and economic factors to modify exhibition techniques and broaden educational objectives in an effort to better serve local communities and society at large (Bloom & Powell, 1984). Increased recognition of the importance of the diversity in our cultural and ethnic heritages, for example, has led to more exhibits that illustrate different customs and ethnic characteristics. Other influential factors are the educational crisis which has encouraged museum professionals to analyze the museum's potential as an alternative educational channel (Shettel, 1991), and the advent of the information age which has created an increasingly complex society dependent upon multiple media for information dissemination and communication (Bloom & Powell, 1984). Specific new issues involving environmental awareness, social values, health, and global politics and economics have also begun to shape the activities of museums.

Using timely and relevant social, political and economic subject matter for exhibits helps museums relate their content to the general population, and also helps the various sectors of society relate to one another (Blackwood, 1992; Gable, 1992; Heartney, 1992; Museum Recalls, 1992; Rist, 1992; Wilson, 1993). One example of such timely subject matter is the first permanent interactive exhibit installed in the American Museum of Natural History (AMNH) called *Global Warming*. Developed in collaboration with tl
Defense Fund (EDF), the exhibit features attention-grabbing music, colors, and animations, and contains four interactive multimedia programs that teach visitors about global warming, how they contribute to it, and how they can help to reduce it (Wertheim, 1992). One program choice allows the visitor to calculate how much they personally contribute to the growing amount of carbon dioxide in the atmosphere. The exhibits use a guideline that designer Jeff Jones always tries to follow: "Start from people's own experience, from things they know and can relate to, then expand their knowledge out from there" (p. 52). Plans are under way to package and market the interactive software to other museums and educational institutions. Another example is *The Kids Bridge* exhibit at the Boston Children's Museum, an interactive videodisc program that allows visitors to "talk to" kids from different neighborhoods in order to better understand racial and cultural diversity.

Of the social forces mentioned, the arrival of the information age has most directly encouraged the introduction of interactive multimedia technologies in museum exhibits. Individuals are now so accustomed to the flood of visual, aural and written information that bombards them daily through television, radio, video, and print media, that they are not only more accustomed to accepting and selectively interpreting all this stimulus, but as several participants from the museum association and expert interviews pointed out, visitors increasingly expect multimedia in every environment they encounter. This volume and diversity of information, however, can still create problems for some individuals who have trouble assimilating the flood, as well as create specific design challenges for museums. Animated, colorful, or "jazzy" presentations of information require more complex communications skills, specifically, multi-media communications skills. Educator and scientist Vannevar Bush recognized the increasing difficulty that individuals would have in processing the ever growing level and types of information, and warned of "information overload" back in 1945 (Solving Information, 1992). Many museum educators would agree that we have reached and surpassed that overload point many times over, and that we need to develop ways to sift through the information that is important to the individual.

In response to these needs for information management and effective education, an increasing number of museums are undertaking creative interactive technology-based educational exhibits which allow individuals to control vast amounts of information and learn based on individual needs and interests (Aarsteinsen, 1992; Booth et al., 1982; Feber, 1987; Harte, 1989; Palmer, 1992; Parr 1992). Tech 2000, a technology gallery in Washington, D.C., has an interactive multimedia program developed by IBM that uses cartoons and commands on a computer screen to teach deaf children to talk. If the sound is pronounced correctly, the monkey cartoon character races up to the top of the tree; if incorrectly pronounced, the monkey remains motionless (Schneider, 1992; Interview: Tech 2000, 1992). Another interactive exhibit called *LIFEmap*, originally developed by the San Francisco-based company Aborescence, has versions installed in the California Academy of Sciences and the American Museum of Natural History's (AMNH) Fossil Hall. This interactive computer program allows users to investigate the tree of evolution, from single celled bacteria to dinosaurs and mammals, learning about how scientists believe life evolved on our planet. The latest version of the program incorporates video segments and computer animation to augment the original version that used mainly still images (Wertheim, 1992; Interview: American Museum of Natural History, 1992). These and other interactive programs are helping to increase the popularity and effectiveness of museums as social and educational environments.

The general excitement over interactive multimedia is rooted in a belief that these technologies work in ways that more accurately reflect the way people think (Ambron & Hooper, 1988; Huston, 1990; Nyce & Kahn, 1991). Vannevar Bush's well-known article, "As We May Think," in the July 1945 issue of the *Atlantic Monthly* was the starting point for virtually all the developments of multimedia we see today, and one of the first to raise the idea of using technology to help us think (personal communication: A. R. Stone, September, 1992).

In "As We May Think," Bush describes an imaginary machine called the MEMEX, which took the form of a multimedia desk equipped with keyboard, microfilm readers and all the tools necessary to allow the user to store and link vast amounts of information in the same way that people tend to think, that is, by association. "With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain" (Bush, reprinted in Nyce & Kahn, 1991, p. 101). The MEMEX would allow the user to quickly and easily access any information needed, but more importantly, would create an intricate web of associative links that would have special meaning to the creator of those links. The hoped for consequence of this system would be that individuals could better manage "information overload," the condition brought about by the growing mountains of research that have not been matched by ways to access the information. Schuman (1990) described the same problem as "access to excess," and Wurman (1989) as "a world that is data rich and information poor" (both cited in Huston, 1990, p. 336). With Bush's article the theoretical foundations for hypertext and multimedia systems were laid.

Several other visionaries were inspired by Bush's article, including Douglas Englebart, who in the 1950's began research on human-computer interactions and how to develop sys-

tems that help us think, and Ted Nelson, who coined the term "hypertext" in 1965 to describe a non-sequential information retrieval system (Seyer, 1991, p. 5). The driving philosophy behind hypertext was that people should be able to access, store and retrieve information in the same natural associative manner that Bush had envisioned. This exploratory navigation through the content of the database is often referred to as "branching," as in, from one branch to the next on a tree, from one idea to the next in the information database (Bush, reprinted in Nyce & Kahn, 1991). Generally the more sophisticated the hypertext system, the more sophisticated are the branching and interaction features.

Hypertext was eventually expanded to include the linking of multiple media - text, sound, video, animation, and graphics - hence the term hypermedia. Multimedia, a term which has already been discussed as having roots much earlier than computers, was adopted by the computer industry as the catchy nickname for the new technologies that melded computers, videodiscs, and now CD-ROM and many others technologies, into an integrated computer controlled system that would make interactive hypertext and hypermedia linking possible. This appropriation of the word multimedia by the technologists seems reasonable given the fact that it was the advent of the microprocessor that lead to programmable hardware for each of the different media disciplines, and the personal computer that brought the ability to combine and control multiple media from one point (Burger, 1993). Multimedia is really neither a specific technology nor a product, though many use the word in that way. Instead it is a communication system; a mechanism for delivering information in intuitive, multi-sensory ways through the integration of disparate media and pieces of information. This integration results in a multi-purpose device that in most cases is under the immediate control of a personal computer, and the ultimate control of the designer and user (Koester, 1991).

McLuhan and Parker were two of the first proponents of multimedia technology in museum exhibition (Alexander, E., 1979). In 1969, they began to explore ways to use technology to enhance communication with visitors, and discovered that the plethora of storyline, linear, detached approaches to exhibition may have suited the objects being displayed, but did not suit the audience. From their research came the idea that bombarding the viewer's senses with various media would stimulate visitors into absorbing more information and retaining it longer (p. 187). It was through McLuhan's discussions with museums that the idea of a "participating" museum came about. The goal was to give equal value to understanding through any of the senses, encouraging visitors to ask questions and creating a much more two-way communication experience (Hudson, 1977, p. 77).

Some of the earliest implementations of interactive technology in exhibits were created in the late 1960's to mid 1970's by Myron Krueger, father of artificial reality (Krueger, 1991). *GLOWFLOW*, *METAPLAY*, *PSYCHIC SPACE*, and *VIDEOPLACE* were four of his exhibits which utilized computer technology and the concept of an artificial, computer-generated reality to create multi-user, human-computer interactive environments. *VIDEOPLACE*, for example, installed in the Milwaukee Art Museum in 1975, involved a room which visitors would enter to face a video-projection screen displaying a silhouette of their live image combined with computer graphics. A large sheet of translucent plastic was placed behind the participant and backlit by fluorescent tubes, producing a high-contrast

image that enabled the computer to distinguish the person from the background through a surveillance camera positioned under the screen. The visitor's image would be digitized and projected onto the screen as a silhouette where it could interact with other visitors' images or with graphics that were drawn into action by the computer artist in another room. Visitors readily recognized themselves in the simulated environment and most learned to communicate with the changing video screen graphics. Activities instigated by the computer/artist included games of cats cradle, playing with graphic "critters," and finger painting (Krueger, 1991). Since that time, numerous other interactive technology-based installations have been tested in museum exhibit halls.

One of the largest interactive exhibits that the Smithsonian had ever put together was installed in May of 1990 when the National Museum of American History opened its *Information Age* exhibit at a cost of over $9 million (Allison & Gwaltney, 1991). Through approximately 700 artifacts, 56 personal computers, 4 workstations, 2 minicomputers, 44 videodisc players, printers, projectors, monitors, a video wall and more, the exhibit teaches about the evolution of electrical and electronic information technology, and how it has affected our society. When the visitor enters the exhibition, they can use their bar-coded brochure to "log in" with the computer network that tracks their progress through the museum from any of the 19 interactive computer or video-based exhibits they visit, and at the end, will provide a printout with the results of their experience. The most popular computer program on the network allows users to encipher their name using a simulation of the German ENIGMA ciphering machine, and then decode it by remembering the machine rotor settings that they used to encode it. The goal of the entire exhibition was to provide an entertaining atmosphere and a full context for understanding the informatio n age (Allison & Gwaltney, 1991).

When computers invaded museums in the 1970's and 1980's, their novelty had almost as big an effect on museum professionals as they did on the audiences (Cassedy, 1992). Many museums were incorporating computers into exhibits because they believed in their drawing power. As the interest in interactive videodiscs grew, and new technologies entered into the education, training, and entertainment fields, so did they in museums (Cassedy, 1992; Helsel, 1990; Information Technology, 1987; McCarthy, 1989; Mintz, 1991). Much of the interactivity in these early stages, however, was simple button pushing, something more than one interviewee referred to as "meaningless interaction" because there was no relationship between what the user did and the information he or she was accessing. Moreover, the early driving force behind the integration of technology in exhibits was often the technology itself, not the belief in the value of selectively interacting with information or in multimedia as a communications tool (Cassedy, 1992; Mintz, 1991). But as the focus has shifted away from the technology to the visitor, the status of multimedia has changed.