twined, coupled with the heterogeneity of the museum audience, makes satisfying each visitor a formidable task. Instead of attempting to meet the needs and wants of every visitor in every exhibit, many designers agree that museums should try to identify the possible motives of the visitor and then do their best to design either separate or integrated exhibits that satisfy each of those motives (Hudson, 1977; Miles et al., 1988; Interviews: The Austin Children's Museum, 1992; The Exploratorium, 1992).

Two other important, fairly generic audience characteristics include the fact that most visitors come to museums in groups or at least couples, and that the average time spent at an exhibit ranges from 5 seconds to two minutes (Lee, 1968; Lewis, 1991; Melton, cited in Special Issue, 1987a; Interviews: Aborescence, 1992; The Exploratorium, 1992; Minneapolis Institute of Art, 1992). Since visiting museums tends to be a social experience, several study participants felt that exhibits should attempt to accommodate more than one person. And with an average attention span of 45 seconds to one minute per exhibit, the design must be attractive and immediately intuitive to capture a passerby (Lee, 1968). Each of these factors carry implications regarding the design of educational exhibits and the need for an engaging presentation of the content.

The Museum as a Learning Environment

Understanding the educational approach used in museums requires an examination of not only the visitor, but of the learning setting. Traditional learning environments, i.e., schools, are often contrasted to museums by describing the former as formal education, and the latter as informal education (Bitgood, 1988; Gardner, 1991a; Shettel, 1991; Vance & Schroeder, 1991). Lee (1968) describes the difference as "learning-from-the-environment" versus the formal "teaching-learning" process used in schools (p. 373). Although both settings are alike in that they aim to inform their audiences, the bottom line is that the museum presents a completely different learning environment from the school. In museums, visitors learn through direct interaction with objects and artifacts, and in the schools, students are generally directed by teachers to absorb predetermined curricula from textbooks. Understanding the similarities and differences between these two approaches to learning helps to highlight the most effective ways to present information given the museum environment.

A common goal of informal and formal educators is to communicate new information to learners. It makes sense then, that exhibit designers often follow many of the information presentation strategies and processes that have been proven by instructional design professionals in formal education contexts. For example, exhibit designers normally define objectives, identify the target audience, identify program resources, design by the objectives, implement, and revise exhibits as necessary - processes advocated by many instructional designers (Dick & Carey, 1990; Mager, 1988; Miles et al., 1988). The success of systematic instructional design processes in schools and corporate training departments has validated their use as an instructional framework, and many museum professionals also recognize the value of these techniques. Exhibit designers, however, tend to vary their "instructional

design" practices to accommodate the informal learning characteristics of their environment by, for example, not mandating that the visitor practice or be tested on the information communicated (Dick & Carey, 1990; Mager, 1988; Miles et al., 1988; Schneider, 1992; Wilson, 1992a; Interview: The (Boston) Computer Museum, 1992).

Along with the similarities in goals and instructional design steps advocated come some very significant differences which make the instructional design process used in schools inappropriate for museums. Brown, Screven, Koran, and Beer (cited in Bitgood, 1988) are a few of the museum evaluators who have identified the key differences between informal and formal learning. They recognize that informal learning practices do not presume to systematically teach the measurable knowledge that formal academic learning does, and instead rely on a "discovery-based" learning approach. Discovery-based or experiential learning is a self-paced educational approach where the goal is to present the learner with a body of information and then allow that person to explore and discover the information in which he or she is interested.

Stephen Bitgood of the Center for Social Design (1988) suggests seven areas in which formal and informal learning differ: instructional stimuli; characteristics of the environment; responses elicited from learners; social interactions; consequences of the learning experience; instructional objectives; and the target audience. Understanding the differences between informal and formal education in these seven areas can not only help designers create educational exhibits for the museum audience, but they can also help identify the unique successes of well designed exhibits to reveal how learning can be made more effective in any environment. Some of these differences within the seven areas defined by Bitgood and supported by findings of other researchers include the following:

Instructional stimuli. The first key difference Bitgood (1988) mentions is that formal education generally uses verbal information to teach, while the informal museum setting uses visual information and is increasingly moving toward multi-sensory stimuli. Formal education typically provides abstract exposure to information, while informal education provides direct and hands-on experiences (Bitgood, 1988; Harte, 1989). Formal education requires extended exposure to information which leads to better retention, while informal education normally consists of short exposures, although repeated visits can increase retention.

Instructional environment. Another difference is that the environment of the classroom is fairly unchanging, whereas that of the museum is more dynamic, possibly distracting. Interest level may remain high in the dynamic environment, but retention for the same reasons is expected to be lower. Unfamiliarity with the informal environment requires the learner to circulate to get exposure to the instructional stimuli in the exhibits. Classrooms, in which students are generally seated and familiar with the surroundings do not encourage this exploration.

Responses elicited from learners. Behavior in formal education is largely teacher-paced with great importance placed on achievement, whereas in museums the pace is normally determined by the visitor/learner and achievement is personal and self-motivated. These differences lead to intrinsic rewards in museums, while in schools, the rewards are more public and contrived (Bitgood, 1988; Gardner, 1991a).

Social interactions. Unlike most formal environments, socializing is accepted and encouraged in informal museum settings. Since most visitors come to museums in groups, learning is treated as a social or family event. Formal school settings on the other hand, have hierarchical structures and educational content which often limit social interactions.

Consequences of learning. Formal education practices use reward and punishment strategies to motivate students (e.g., grades, teacher and parent approval/disapproval, acceptance to college). Informal environments do not threaten the visitor with negative consequences. Instead, they encourage intrinsic rewards with fun and casual activities. The attitude towards, and implications of learning are much more positive (Harte, 1989). However, a possible negative effect due to the lack of supervision and direction in museums may be that the learner is misinformed (Bitgood, 1988).

Exhibit 2
Summary of the Differences Between Informal and Formal Learning Environments

	Schools	Museums
Instructional Stimuli	verbal & visual; abstract; extended exposure	visual & multisensory; direct exposure/hands-on; short duration
Learning Environment	unchanging; familiar;	dynamic;unfamiliar;exploratory
Responses Elicited	teacher-paced; performance-based;	self-paced; self-motivated
Social Interactions	limited; individual focus	accepted/encouraged; group focus
Learning Consequences	reward or punishment	intrinsic rewards; low supervision
Instructional Objectives	quantitative; facts & knowledge; performance standards	experiential; affective; observation evaluations
Audience Characteristics	categorized	diverse

Instructional objectives. Formal education demands learning specific concepts and facts, which are mostly quantitative and cognitive activities. When textbook or course evaluations are conducted in formal education, there is little leeway in what is considered appropriate or adequate information and performance. The objectives of museum education are more experiential and affective. In informal learning, evaluations tend to focus on the quality of the experience, not on the quantity or retention of facts.

Audience characteristics. Finally, Bitgood notes the difference in the audiences: formal learning categorizes learners, usually by age or aptitude, whereas informal learning is open to any learner, potentially creating a much more diverse audience.

While many of the differences mentioned are broad generalizations, and while some of these differences are decreasing as schools initiate changes to improve learning and museums offer more classes and workshops, several researchers would probably still agree with the characteristics listed by Bitgood (Chenoweth, 1990; Gardner, 1991a; Harte, 1989; McCarthy, 1989; Wilson, 1987 & 1987). Maton-Howarth (1990) adds that secondary education is *not* primarily concerned with, nor designed to develop life skills and values (e.g., individuality, creativity, sensitivity, perception), but does efficiently impart factual knowledge that meets the needs of society (pp. 183-184). Museums, on the other hand, *are* equipped to offer meaningful, life-oriented education through interactive and experiential learning, and therefore, can potentially provide more effective learning experiences that better equip individuals for everyday life (pp. 182-185).

Although the differences listed above may appear to praise informal education at the expense of formal education, Bitgood (1988) readily states that informal learning institutions are not without their adverse consequences, namely the possibility of misinformation, the boring quality of numerous similar objects in some exhibitions, long hours walking, and the possibility of ill-designed instructional aids (e.g., tiny or poorly worded labels). Bitgood's conclusion is not that informal institutions can replace formal institutions for learning, but that the two should learn from each other and cooperate to accomplish their goals in harmony.

While most academic educators and museum exhibitors would agree that informal education will never substitute for formal education, Gardner, a Harvard University researcher, feels that schools should be made more like museums in order to foster true understanding of concepts in the world around us (Gardner, 1991a). At least one example of a formal educational program that is taking steps to combine the best of the classroom with the science museum approach to presenting information is Project Science 2000 ("Science 2000," 1992). Science 2000 classrooms use teachers to lead discussions, and then move to hands-on experiments and activities so that students can play the role of scientist, using real scientific instruments to forecast the weather, for example. Gardner's hope is that more schools will seriously study the strengths of museum programs that incorporate activity- and discovery-based learning of valuable life issues, and determine how to incorporate those qualities into traditional teaching methods (Gardner, 1991a).

Zeller also feels museums offer significantly different learning from schools: "trying to make the museum experience an extension of the classroom...over-shadows the unique learning opportunities of the museum...and makes the museum into a school rather than emphasizing the characteristics that makes it a different and unique learning environment" (Zeller, cited in Maton-Howarth, 1990, p. 187). Zeller, Gardner (1991a) and Bitgood (1988) pose ideas that are on the minds of many educators and museum professionals. Given the existing infrastructure and capabilities of museums, it seems only logical that museums play a significant role in the effort to educate the public by expanding and strengthening their informal educative role, and by working with formal education systems (Excellence and Equity, 1992; Gardner, 1991a; Harte, 1989; Healy, 1992; Shettel, 1991). The NSF funding for science museum teacher training programs mentioned earlier is an example of how a more closely woven relationship between museums and traditional educational channels can exist (Chenoweth, 1990).

A large part of the action taken in response to the issues of improving school and museum education has been to increase the use of hands-on and participatory learning, and to incorporate interactive technologies (e.g., videodiscs and computers) in both formal education and museum exhibits (Abbe, 1992; Gable, 1992; Information Technology, 1987; Palmer, 1992; Special Focus, 1991; Interviews: International Business Machines, 1992; California Museum of Science and Industry, 1992). Multimedia in particular, is having a significant impact on the education and training communities because of its new and dynamic approach to communicating information (Ambron & Hooper, 1990; Eiser, 1992; Helsel, 1990; Jostens Announces, 1992; McCarthy, 1989; Perry, 1990; Special Focus: Education, 1991; Special Focus: Training, 1991). With respect to learning, multimedia provides the opportunity to absorb information communicated through a number of media, where each stimulus can act as a reinforcement of the same message. Cognitive research has shown that presenting an image accompanied by text or sounds reinforces learning (McCarthy, 1989, p. 27). Perhaps most importantly, the multimedia experience can address different learning styles - those who are more visual can access or concentrate on video or animations as their source of information, those who are more comfortable understanding ideas presented through text can choose to read, and so on.

Gardner (1991b) has identified *seven human intelligences*, that is, seven different modes that all individuals use in varying degrees to understand the world. The tenets of multiple intelligence (MI) theory are that individuals can use language, logical mathematical analysis, spatial representation, musical thinking, and the use of the body to solve problems and make meaning (p. 12). Gardner's conclusion is that some individuals learn more easily through linguistic methods, others through spatial or mathematical means. This being the case, multimedia technologies afford personalized learning systems that can work for anyone. And being able to accommodate these different learner preferences and abilities provides a very rich and thorough educational interaction (McCarthy, 1989; Mintz, 1992; Special Focus: Education, 1991; Special Focus: Training, 1991; Wilson, 1987).

Another benefit of interactive multimedia relevant to the museum context is that learning is transformed from a passive, read the book or listen to the lecture approach, to a much more active, learner-paced and discovery-based educational experience (Miles et al., 1988,

p. 95; McCarthy, 1989; Interviews: Merrill-SALT, 1992; IBM, 1992). Not only does multimedia empower individuals by giving them greater control over their learning, but the development of easy to use programming tools have made it possible for the learner to create his or her own multimedia presentations. This potential has already begun to revamp the idea behind a "term paper," as shown in schools which are allowing kids to create and deliver multimedia presentations on computers instead of paper (McCarthy, 1989; Wilson, 1991). Students are also developing higher-order problem solving skills, cooperation, and group communication skills; the latter two representing interesting side affects from the inability to fund more than one computer per three to four students (McCarthy, 1989; Wilson, 1991). Other benefits include the ability to customize programs for different grades and achievement levels, to record and store multiple languages in a single program, and to track student progress. In training, interactive technologies have been praised for reducing costs and improving retention (Guglielmo, 1992; Special Focus: Training, 1991, p. 80). Finally, the technological capabilities of the magnetic and optical media in these systems provide reliable, high quality storage of massive amounts of information.

Many schools which have implemented multimedia technology have seen extremely positive results in the form of improved motivation, retention, learning speed, self-esteem, and interest in learning - some of the most common and devastating reasons why education seems to be failing today (Davey, 1991; McCarthy, 1989; Perry, 1990; Special Focus: Education, 1991; Wilson, 1987; Interviews: Bank Street College of Education, 1992; Texas Learning Technology Group, 1992). Given the fact that people generally remember 25 percent of what they see, 40 percent of what they see and hear, and 75 percent of what they hear, see, and do, the logic of involving students in interactive multisensory learning opportunities is clear (Multimedia : up close, 1991, p. 10). Two specific examples of successful educational multimedia projects include the Texas Learning Technology Group (TLTG) and Bank Street College initiatives, which have very successfully focused on using multimedia technology with a discovery-based learning approach in an effort to make school learning more engaging and relevant to students.

TLTG is a partnership of 13 Texas school districts, the National Science Foundation, and the Texas Association of School Boards, formed to develop high school applications in science and math using advanced technologies. TLTG's first project, a complete physical science curriculum built around 460 hours of instruction on 15 videodiscs and accompanying resource guides, has proven to be a great success. The seventeen states now using the "Introduction to Physical Science" program have reported failure rates in physical science at under 5%, a figure that becomes astonishing when made aware of the nationwide 50% failure rate for physical science courses not using this program (Interviews: TLTG, 1992; Society for Applied Learning Technology [SALT], Bozman, MD, 1992).

Similarly impressive results have been found through research done by the Center for Technology in Education at the Bank Street College of Education. *Interactive Nova: Animal Pathfinders*, a prototype program using HyperCard to control a videodisc player was used along with two other prototype videodiscs, National Geographic's *Whales* and Bank Street College's *The Voyage of the Mimi*, to study the nature and value of using interactive multimedia in the classroom. After six weeks in a fifth-grade classroom, these multimedia

tools were being used by the children for games, research, and most significantly, for the creation of individual and collaborative presentations and interactive multimedia reports (Wilson, 1991).

The Society for Applied Learning Technology (SALT) has tracked over a hundred other schools and training centers that have implemented multimedia technology and reported higher grade point averages, faster and greater retention of content, and other improvements that speak in terms of advancing grade-levels, increased attendance and decreased drop-out rates. Merrill (1992) has also tracked corporate training departments which have reported similarly positive results from the use of interactive multimedia programs, including reductions in training time of over 40% (Interview: SALT, Bozman, MD, 1992).

So how do all these benefits translate to the museum environment? Granted, the in-depth educational applications developed for schools and other training programs would hardly be necessary or appropriate in the generally short-lived and informal museum visit. Nonetheless, interactive multimedia technology offers the opportunity to present a large amount of information in a small space, and can make use of our instinctively powerful senses of sight, hearing, and touch. Two experts and an independent exhibit designer interviewed for this study stated that they felt the positive results of multimedia in education could transfer to the museum environment, that is, museums could use the successes of interactive multimedia in education as an important corollary and reason to use multimedia in museums. Unfortunately, these experts also agreed that the majority of museums do not know about the research that has been conducted on multimedia in education, just as many museums apparently do not conduct enough of their own research into the costs, into what technology is available, and into the experiences of other museums with technology in exhibits.

The unique characteristics of an informal learning environment both place and alleviate burdens on the museum exhibit designer who wishes to educate. Because visitors are more likely to be distracted by competing exhibits and the social interactions allowed in museums, exhibits need to be much more attractive and engaging than a textbook. The differences in the skills and knowledge levels of the audience also make the design process much more complicated. On the other hand, because the objectives of museum education are often not to impart concrete educational content, but are often qualitative and attitudinal in nature, the attention to the rigors of presenting objectives, practice and testing are not necessary. Consequently, except for some museums that present the objectives up front, the instructional design principles of presenting objectives, practice, and testing are generally not used in museum exhibits (Bitgood, 1988; Miles et al., 1988; Interview: The Austin Children's Museum, 1992). Instead, edutainment strategies which combine attention grabbing techniques with opportunities to learn based on individual motives and interests, dominate exhibit designs.