UNIVERSAL DESIGN

Literature Review

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Universal Design Literature Review

The following document summarizes results from a literature review conducted in Fall 2004 to inform the development of a nationwide research project that will explore universal access to the learning of science, technology, engineering, and mathematics (STEM) in museums. Through this project, the Museum of Science, with four collaborating institutions, will further the industry's knowledge and understanding of ways to create museum exhibitions that are inclusive of the learning needs of all museum visitors, including those with disabilities.

Guiding the literature review was a topical framework that addressed the research topics each collaborating institution proposed for their research study. The document is organized around this topical framework, which is provided below.

UD Literature Review Topical Framework

1) What is universal design?
2) What do we know about current efforts to include persons with disabilities as part of the museum audience?
3) What does the existing literature tell us about ways museums can use information technology to enhance access for visitors with disabilities?
4) What does the existing literature tell us about ways museums can use audio as a tool to make interpretive and instructional label copy accessible to a broader audience?
5) What does the existing literature tell us about how museums can use diagrams, drawings or photos to make exhibit label copy accessible to a broader audience?
6) What are the best practices for including people with disabilities in research and evaluation studies?

7) What does existing research tell us about best practices in the design and functionality of early childhood spaces in variety of settings, such as: schools, day care centers, children's hospitals, museums, mall play spaces, and amusement parks?

8) What does existing research tell us about best practices in the design and functionality of laboratory spaces in variety of settings, such as: industry, universities, elementary and secondary schools, and museums?

Question 1: Defining universal design

According to the Center for Universal Design, universal design is defined as:

> *The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design (Center for Universal Design, 2002).*

Universal design is a democratic design philosophy that promotes inclusion and access for all through a designed environment that does not stigmatize based on physical differentiation. Iwarsson and Stahl consider universal design to be about "changing attitudes throughout society, emphasizing democracy, equality and citizenship" (Iwarsson & Stahl, 2003). For this reason, the authors state, "universal design denotes more of a process than a definite result." Advocates of universal design believe that this process creates environments that are better for everyone. Story, a researcher from the Center for Universal Design, tells us "Successfully designed universal solutions do not call attention to themselves as being anything more than easier for everyone to use, which is exactly what they are" (Story, 1998).

Universal design is not the only method used to create environments that include the needs of persons with disabilities. Other approaches include accessible design, and assistive technology. While these terms are often used interchangeably and imply relatively similar goals, there are subtle differences in these approaches that define the end product.

Assistive technology focuses on the creation of products tailored to the specific needs of an individual, to be used by that individual as he or she navigates through an environment (be it virtual or real). A wheelchair is an example of assistive technology. Accessible design focuses on designing environments to be used by everyone and include the needs of individuals who have disabilities. Accessible design takes into the consideration how the person and the assistive technology interact with the designed environment (for example, curb cuts take into consideration that some individuals use wheelchairs to move around the designed environment).

Those who advocate for the use of universal design differentiate universal design from accessibility and assistive technology. Accessibility is often defined as the adherence to specific codes or requirements created specifically for persons with disabilities (Iwarsson & Stahl, 2003; Story, 1998). Iwarsson and Stahl (2003) tell us that accessible design is generally measured quantitatively (how well you meet required specifications) with little to no input from the actual users, as compared to universal design where user input is a critical part of the design process. Story (1998) feels that the concept behind accessible design leads to stigmatization of persons with disabilities, as the adherence to the mandated codes often leads to "separate design features for 'special' user groups," which "segregate people with disabilities from the majority of the users and make them feel out of place."

Universal design is the application of a design philosophy that strives to create experiences that are accessible to users along a broad spectrum ranging from able to disabled. A central tenet of universal design is that the location of a person on this spectrum is a result of both individual needs and the design of the environment. Universal design focuses on the users at the far end of the spectrum, and tries to determine ways these individuals can become more "able" to complete a given task. It is assumed that if their needs are met, access will increase for everyone in between. As stated by David Rose and Anne Meyer:

> *Traditional views of disability… suggest that a person either does or does not belong to the category "disabled". New understanding … shows that abilities in many domains fall along a very large number of continua. Further, the importance of a particular strength or weakness depends upon what is being asked of the learner. That is why, for example, a youngster with perfect pitch who*

has difficulty recognizing letters is seen as disabled, but a child who is tone deaf but can read words easily is not (Rose & Meyer, 2002).

This conception of universal design is a reflection of the social model of disability, where it is the environment and cultural attitudes that define whether a person is “able” or “disabled”, and not the physical attributes of the person. According to Carol Gill “…disability is a dimension of human differences (and not a defect), [and] derives its meaning from society’s response to individuals who deviate from cultural standards…(Gill, 1999)” This model, Dr. Gill tells us, is different from previous cultural models or definitions of disability such as the “moral model” where disability is a punishment for bad behavior or the “medical model” where disability is considered a medical defect that should be treated or fixed (Gill, 1999).

Universal design also reflects a push towards creating environments that promote inclusion, as opposed to “separate but equal” accommodations for persons with disabilities. Blamires (Blamires, 1999) considers inclusion to be an essential element in the universal design of learning environments. He defines inclusion in three different categories: physical, social and cognitive, and considers inclusion to be a function of both access to and engagement in a learning experience. In the United Kingdom, the term “inclusive design” is often used in place of “universal design.” In 2004, new inclusive design codes were created for the City of London[1] (Fleck, 2004). This document lists three defining characteristics of an inclusive design:

- Can be used safely and easily by as many people as possible without undue effort, separation or special treatment;
- Offer the freedom to choose and the ability to participate equally in the development’s mainstream activities; and

- Value diversity and difference.

In addition to what is trying to be achieved, universal design is also defined in terms of *how* it can be achieved. A number of authors have developed "Principles of Universal Design" that define criteria for judging whether or not an experience is a universal design. The most notable example is the list of "Principles of Universal Design" developed by the Center for Universal Design (Story, 1998):

- Principle 1: Equitable use
- Principle 2: Flexibility in use
- Principle 3: Simple and intuitive
- Principle 4: Perceptible information
- Principle 5: Tolerance for error
- Principle 6: Low physical effort
- Principle 7: Size and space for approach and use

Based on the principles created by the Center for Universal Design, the "Principles for the Universal Design of Instruction" present an alternative framework tailored specifically to formal learning at the university level (Bowe, 2000):

- Equitable use
- Flexibility in use
- Simple and intuitive instruction
- Perceptible information
- Tolerance for error

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[1] This document includes codes for cultural institutions and museums.

- Low physical effort
- Size and space for approach and use
- A community of learners
- Instructional climate (welcoming and inclusive environment for learning)

The Center for Applied and Specialized Technologies (CAST) also developed a set of principles of universal design, which they created to address the development of curriculum and multimedia learning experiences for the K-12 classroom (Rose & Meyer, 2002):

- To represent information in multiple formats and media;
- To provide multiple pathways for student's action and expression; and
- To provide multiple ways to engage students' interest and motivation.

Few studies have examined the effectiveness of applying any of the above stated principles to create environments that are "better for everyone." One exception is a study conducted at the Lighthouse, Inc. building in New York City examining reactions to, and use of, a universally designed building by both disabled and abled participants (Danford, 2003).The results of this study were mixed. While both the abled and disabled participants were able to successfully navigate through the building, the disabled participants stated that the design of the building was better than most they had visited, but the abled participants did not agree that the building's design was better than most. Another example is a study that compared how both abled and disabled students performed on a test that met the principles of universal design and one that did not (Johnstone, 2003). The results of this study were more positive than the Lighthouse, Inc. building study as it found that all students, including those with disabilities and those without, performed better on the test designed using the principles of universal design.

Suggested resources for further reading

Blamires, M. (1999). Universal design for learning: re-establishing differentiation as part of the inclusion agenda? *Support for Learning, 14*(4), 158-163.

Bowe, F. G. (2000). *Universal design in education: Teaching nontraditional students*. Westport, CT: Bergin and Garvey.

Center for Universal Design. (2002). *Definition of universal design*. Retrieved November, 2002, from http://www.design.ncsu.edu/cud

Danford, G. S. (2003). Universal Design: People with vision, hearing and mobility impairments evaluate a model building. *Generations, 27*(1), 91-95.

Fleck, J. (2004). *Accessible London: achieving an inclusive environment*. London, UK: Greater London Authority.

Gill, C. J. (1999). Invisible ubiquity: The surprising relevence of disability issues in evaluation. *American Journal of Evaluation*, *20*(2), 279-289.

Iwarsson, S., & Stahl, A. (2003). Accessibility, usability and universal design- positioning and definition of concepts describing person-environment relationships. *Disability and Rehabilitation*, *25*(2), 57-66.

Johnstone, C. J. (2003). *Improving validity of large-scale tests: Universal design and student performance (Technical Report 37)*. Minneapolis, MN: University of Minnesota, National Center for Educational Outcomes.

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. Alexandria, VA: Association for Supervision and Curriculum Development.

Story, M. F. (1998). Maximizing usability: the principles of universal design. *Assistive Technology*, *10*, 4-12.

Question 2: Persons with disabilities as a museum audience

Over the last twenty years, museums across the United States have increasingly incorporated the needs of diverse learners when creating exhibitions. Numerous publications, websites, and professional development workshops have been developed that provide architectural guidelines for creating accessible exhibitions. These guidelines are based on federal standards and regulations, such as the Americans with Disabilities Act (ADA). Some of the more noteworthy publications include *Everyone's Welcome* (American Association of Museums, 1998), *The Smithsonian Institution's Guidelines for Accessible Museums* (Smithsonian Accessibility Program, 1996), *Hands-on Exhibits that Work* (Kennedy, 1997), *New Dimensions for Traditional Dioramas* (Davidson, 1991), and the Museum of Science's *Universal Design* website (Museum of Science Boston, 2001).

While the publications and efforts listed above have led to significant changes in the industry, they predominately focused on providing physical access to museums and did not address providing intellectual access to learning. Understanding physical differences among individuals and the resulting space and architectural requirements are an important first step. However, this information is not sufficient for providing true access to learning for all. Universal design for learning goes beyond physical accessibility. It involves creating multi-sensory, multi-modal learning experiences from which all visitors can learn by touching, seeing, listening, smelling, and sometimes even tasting.

In 1999 the Association of Science-Technology Centers (ASTC) began an "Accessible Best Practices" initiative to increase awareness of federal regulations and accessible design to science center professionals (Association of Science-Technology Centers, 2000). This effort resulted in the increased attention towards access-related issues at annual science center conferences. According to George Hein, the evaluator for the project:

> *Both directly and indirectly the Accessible Practices project has had an increasing impact on the content of the ASTC meetings. The total number of sessions devoted to accessible practices has increased annually. (Hein, 2002)*

Museums are also increasingly including visitors with disabilities in both formative and summative evaluation of exhibitions. Examples include the formative evaluation of the Smithsonian Institution's traveling exhibition *Invention at Play*, the summative evaluation of the most recent traveling exhibitions created by the TEAMS 2 collaborative, the summative evaluation conducted by the Institute for Learning Innovation of the traveling exhibition *Dogs! Wolf, Myth, Hero and Friend*, and the formative and summative evaluation of the Museum of Science's *New England Lifezones, Secrets of Aging* and *Making Models* exhibitions.

While these efforts are notable, there exists an absence of visitor *research* related to the universal design of museum exhibitions. A search for articles in a database focused on museum learning (www.informalscience.org) found fewer than 10 papers that address accessibility or disability and learning in museums.[2] Less than one third of these 10 papers were research-based, and almost all were unpublished Master's Theses that did not address accessibility in museum exhibitions. A similar search conducted using the Educational Resources Information Center (ERIC) database found only 13 citations related to accessibility or universal design and museums. Two of these articles were research-based, and neither addressed science education or museum exhibitions. The only published articles located through the literature review that presented results for a study of accessibility in exhibitions include the study of the *New England Lifezones* gallery that was conducted at the Museum of Science in the late 1980's (Davidson, 1991), and studies that address the needs of older adults as museum learners (Kelly, Savage, Landman, & Tonkin, 2002; Reich & Borun, 2001).

The search results listed above echo the findings of Steve Tokar, a graduate of the John F. Kennedy University Department of Museum Studies whose Master's Thesis focused on the application of universal design by museum exhibition developers.

> *At present, universal design in museums remains under-evaluated. There has been very little formal visitor research and evaluation specifically designed to measure the effectiveness of UD in hands-on science museums. Many people I spoke with had a great deal of anecdotal information at their disposal—at the Museum of Science, there are notes and records going back over 10 years—but extremely little in the way of summative evaluations published in peer-reviewed journals. Such research studies are unlikely to take place unless funding for them is budgeted into exhibition grant proposals. (Tokar, 2003)*

A few studies are currently underway that focus on the use of digital handheld devices to provide access to learning in museums for persons with disabilities (Brookfield Zoo, 2002; Giusti & Landau, In press; Kirk, 2001; Tate Modern, 2004). These efforts, however, are focused on creating assistive technologies that supplement a user's experience in an exhibition, and do not examines ways to make the actual exhibitions accessible to a broader audience. As discovered in an evaluation of an audio tour at the New York Hall of Science, simply adding assistive technologies to an inaccessible exhibition is not sufficient for creating an environment where visitors with disabilities can learn (Friedman, 2000).

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[2] This search was performed using a variety of related keywords, including disabled, handicapped, access, accessibility, disability, wheelchair, blind, deaf, vision, hearing, universal and disabled.

There is also little information about the museum going habits of persons with disabilities. It is difficult to find data that estimates the number of people with disabilities who attend museums on a regular basis, or information about who visitors with disabilities attend museums with. In the 1995 report “Who Attends Our Cultural Institutions? A Progress Report” produced by the Smithsonian Institution, there is no mention of persons with disabilities as a museum-going audience (Doering, 1995). Again, in the 1998 Museum News article “Visitors: Who does, who doesn’t and why,” no mention is made of persons with disabilities and their presence (or lack thereof) in the museum-going population (Falk, 1998).

While the number of persons with disabilities who attend museums is still unknown, this population could potentially represent a significant portion of the museum audience. In the 2000 U.S. Census, close to 50 million people, 19 percent of the US population, reported that they had a “long-lasting condition or disability” (Waldrop & Stern, 2003). The percentage of the population that has a disability is expected to increase during the next 30 years. By the year 2030, it is predicted that 20 percent of the US population will be over 65 years of age as compared to 13 percent in the 2000 census (Federal Interagency Forum on Aging-Related Statistics, 2000). While growing older does not guarantee the development of a disability, the percentage of the population with a disability increases with age. While 19 percent of men and 16 percent of women aged 16 to 64 reported having a disability in the 2000 Census, for the population aged 65 and older, the percentage rose dramatically to 40 percent of men and 43 percent of women (Waldrop & Stern, 2003). If museums are going to provide a learning environment for all people, attention will need to be given to designing exhibits and programs that accommodate a wide variety of needs.

Suggested resources for further reading

American Association of Museums. (1998). *Everyone's welcome*. Washington D.C.: American Association of Museums.

Association of Science-Technology Centers. (2000). *Accessible practices*. Retrieved January, 2004, from http://www.astc.org/resource/access/index.htm

Brookfield Zoo. (2002). *Every student is a scientist: Using technology to foster inclusive learning*. Retrieved October 7, 2004, from http://www.imls.gov/grants/museum/pdf/mosample.pdf

Davidson, B. (1991). *New dimensions for traditional dioramas: Multisensory additions for access, interest, and learning*. Boston, MA: Museum of Science.

Doering, Z. D. (1995). *Who attends our cultural institutions? A progress report*. Washington, DC: Institutional Studies Office Smithsonian Institution.

Falk, J. (1998). Visitors: Who does, who doesn't and why. *Museum News, 77*(2), 38-43.

Federal Interagency Forum on Aging-Related Statistics. (2000, August 09, 2000). *Older Americans 2000: Key Indicators of Well-Being*. Retrieved December 2003, from http://www.agingstats.gov/chartbook2000/population.html

Friedman, A. J. (2000). Expanding audiences: the audio tour access project at the New York Hall of Science. *Dimensions*, 7-8.

Giusti, E., & Landau, S. (In press). Accessible science museums with user-activated audio beacons (working title). *Visitor Studies Today*.

Hein, G. (2002). *Accessible Best Practices facilities and visitor services workshop summative evaluation*. Cambridge, MA: Lesley University Program Evaluation and Research Group.

Kelly, L., Savage, G., Landman, P., & Tonkin, S. (2002). *Energised, engaged and everywhere: Older Australians and museums*. Canberra, Australia: Australian Museum and the National Museum of Australia, Canberra.

Kennedy, J. (1997). *User Friendly: Hands-On Exhibits That Work.* Washington DC: Association of Science-Technology Centers, Inc.

Kirk, J. (2001, March 15-17). *Accessibility and new technology in the museum.* Paper presented at the Museums and the Web, Seattle, WA.

Museum of Science Boston. (2001, 2001). *Universal Design (Accessibility)*. Retrieved December, 2003, from http://www.mos.org/exhibitdevelopment/access/

Reich, C., & Borun, M. (2001). Exhibition accessibility and the senior visitor. *Journal of Museum Education*, *26*(1), 13-16.

Smithsonian Accessibility Program. (1996). *Smithsonian guide for accessible exhibition design*. Washington, D.C.: Smithsonian Institution Press.

Tate Modern. (2004). *Tate Modern Multimedia Tour*. Retrieved October 8, 2004, from http://www.tate.org.uk/modern/multimediatour/reseval.htm

Tokar, S. M. (2003). *Universal Design: An Optimal Approach to the Development of Hands-on Science Exhibits in Museums.* Unpublished Master of Arts in Liberal Studies, John F. Kennedy University, Pleasant Hill, CA.

Waldrop, J., & Stern, M. (2003). *Disability Status: 2000*. Retrieved December, 2003, from http://www.census.gov/prod/2003pubs/c2kbr-17.pdf

Question 3: Information technology as a tool for universal design

Museums have begun to explore how information technology can be used to create learning environments that are inclusive of the needs of persons with disabilities. A number of studies are currently underway or have recently been completed that focus on the use of digital handheld devices to provide access to learning for persons with disabilities (Brookfield Zoo, 2002; Giusti & Landau, In press; Kirk, 2001; Tate Modern, 2004). While noteworthy, none of these studies have focused on the universal design of computer kiosks in museums, despite the fact they are commonly used in museum exhibitions (Reich, 2002).

Museum guidelines such as those created by the Smithsonian Accessibility Program (Smithsonian Accessibility Program, 1996) and the American Association of Museums (American Association of Museums, 1998) provide information on the design of the kiosk that houses a computer interactive and limited information about the controls. These guidelines, however, do not address the actual user interface. The ASTC accessible best practices website does contain some information on making museum websites accessible to visitors with disabilities, but this information is not directly applicable to the design and planning of information technologies for use in exhibitions (Association of Science-Technology Centers, 2000). Only a few museums or groups have made significant contributions to this area, the most notable example being the Museum of Science in Boston (Museum of Science Boston, 2001).

Despite the lack of data available in the museum field, universal design research performed in the fields of assistive technology, web site development, educational technologies, and for-profit software development is applicable to museums. Lessons learned from these fields can serve as a starting point for museums as they develop strategies to use digital media to enhance access for all.

Information technology as a tool for universal design

Today, museums have a new tool available– digital media and information technology. The inherent flexibility of this new tool offers museums a new opportunity to reach broad audiences through customization and choice. The Center for Applied Special Technologies (CAST) has been advocating for the use of information technology in the classroom as a means for increasing access to independent learning for all students, including those with disabilities (Rose & Meyer, 2002). Additionally, Oce Harrison, Project Director for the New England ADA and Accessible IT Center also feels that information technology proposes a solution that can help ensure that "no child is left behind":

> *We are living in a time when educating students presents both a great challenge and opportunity. Recent K-12 federal policy states that the great challenge is 'not to leave any child behind.'…A great opportunity lies in utilizing the potential of technology for addressing diverse learning needs. With the developments in information technology and the increasing digitization of the curriculum, teachers have the opportunity to offer even more flexibility in tailoring instruction to diverse learning needs. In order to be present to both the challenge and the opportunity in education, we must provide equality of access to information technology and the educational curriculum to students (Harrison, 2002).*

Interestingly, studies conducted in the field of multimedia learning have demonstrated that the use of multimedia to deliver content simultaneously through both images and audio has a positive impact on learners who do not have disabilities. One study of second-language learners found that students were better able to recall the meaning of words when they were presented with both visual and verbal representations of the terms (Jan L. Plass, Dorothy M. Chun, Richard E. Mayer, & Detlev Leutner, 1998). In another study, students' ability to remember weatherrelated content and apply that content to problem-solving increased when the students looked at a computer animation and heard a description of the content read aloud, as opposed to when the students watched the animation along with text written on the screen (Meyer & Moreno, 1998). While these studies did not include students with disabilities in the testing, nor did they specifically address the principles of universal design, they do suggest that software designed to include persons with disabilities (such as the simultaneous presentation of information through audio, images and text) may in fact create experiences that benefit all learners.

Existing guidelines and standards

Over the past five to seven years, a number of guidelines have been produced within the fields of web design and new media that provide standards, techniques and strategies for providing universal access to information (Burgstahler, 2002; Chisholm, Vanderheiden, & Jacobs, 1999; Kara P. Coyne & Nielsen, 2001; Foley & Regan, 2003; Freed, Rothberg, & Wlodkowski, 2003; "Rehabilitation Act," 1998; Schmidt & Wlodkowski, 2003; Spry Foundation, 1999; Vanderheider, 1994). Review of these guidelines reveals that certain recommendations are consistently repeated. Table 1 provides a quick list of the repeated recommendations that would most apply to the design of computer kiosks for use in museums, along with characteristics of the learners who would benefit from their inclusion in the design of multimedia components.

TABLE 1: ESSENTIAL DESIGN FEATURES UNIVERSAL ACCESS TO INFORMATION THROUGH DIGITAL MEDIA	
Feature	**Audience members who benefit**
Captioning of all audio and video contained in digital media presentations	Visitors who are deaf and hard of hearing (including older adults)
Audio descriptions for videos, images, and other visually-based presentations	Visitors who are blind and have low vision, and visitors with cognitive impairments that have difficulty interpreting images
Text-to-speech capabilities (text is read aloud to the visitor)	Visitors who are blind or have low vision, younger visitors who are learning to read, visitors with cognitive impairments or learning disabilities, and visitors whose first language is not English
Easy to read text (high color contrast; a large, clear type-face; and ample space between lettering and text lines)	Visitors with low vision (including older adults) and visitors at extreme heights (low and high) who may be subjected to glare from the overhead lighting
Images that convey content	Younger visitors learning to read, visitors with cognitive impairments, and visitors who speak English as a second language (including those who use ASL)
Minimized flickering of images	Visitors who are subject to seizures
Use of the clearest, simplest text possible	Younger visitors learning to read, visitors with cognitive impairments, and visitors whose first language is not English (including those who use ASL)
Text that makes sense when read aloud and not viewed graphically (such as "**Return to main menu**" vs. "**Main Menu**")	Visitors who are blind or have low vision (and are relying on the text-to-speech function), visitors with cognitive impairments, and visitors who are not frequent computer users
Present information in a clear, consistent and repetitive layout	Visitors with cognitive impairments, visitors who are blind or have low vision (and therefore need to rely heavily on their auditory memory to navigate the interface), older adults and infrequent computer users
Limit the number of choices available on the screen at any point in time	Visitors who are blind or have low vision (and have to rely on their auditory memory to access information), and visitors with cognitive impairments
Minimize the need for scrolling on the screen	Visitors with low vision and visitors who have learning disabilities
Control over the pace at which visitors receive information	Visitors who take longer to read than other individuals, such as those who have low vision, learning

	disabilities, and young children

Assistive technology and other operational controls

There are a number of assistive technologies on the market that persons with disabilities can use to access their personal computers. Examples of adaptive software include the following:

- Screen readers, which read aloud text as it appears on the screen, are commonly used by people who are blind, and some persons with reading disabilities;
- Voice recognition software can be used by persons with limited mobility;
- Sign language software can assist persons who are deaf;
- Screen magnifiers, which magnifies images and text on the screen, are often used by persons with low vision; and
- Eye-movement interfaces, which track your eye movements and move the cursor accordingly, can be used by persons who are paraplegic and have limited use of their voice.

Examples of hardware that serve as assistive technologies include the following:

- Braille displays and printers;
- Joystick style mouses (which can be operated by hand or using mouth controls), trackballs and switches. These can be used by persons with limited upper body mobility;
- Ergonomic and specially designed keyboards made for one-handed use or to reduce repetitive injuries; and
- Brain-activated interfaces that provide a way for a computer user to *think* about an action and have the computer respond.

The Rochester Institute of Technology's EASI web site provides a complete list of current assistive technologies available on the market, along with links to the developer's web sites (http://www.rit.edu/~easi/). Other useful resources include "Adaptive Technologies for Learning & Work Environments" (Lazzaro, 2001), and "Extra-Ordinary Human-Computer Interaction" (Edwards, 1995). While none of these technologies are examples of universal design, there is the possibility that they could be used to expand access to computers to a broader audience in museum exhibitions.

Assistive technologies for wayfinding

Wayfinding in museums is a difficult endeavor for visitors who are blind. A few museums, including the Museum of Science, the New York Hall of Science and the Mashantucket Pequot Museum, have recently acquired assistive technologies that can assist visitors who are blind in finding their way around museums. While none of these systems are examples of universal design, they could be adapted to meet the wayfinding needs of a broader audience. One example is the *Talking Signs* system installed at the Museum of Science, Boston and the Mashantucket Pequot Museum. This technology uses infrared sensors to provide location-based auditory directions to visitors carrying a handheld beacon. The *Talking Signs* technology has been shown to be a highly effective wayfinding device for users with visual impairments, both in museums as well as campus and city-wide usage (Marston, 2002). Another technology is a tactile/ auditory map, also installed at the Museum of Science, Boston, and in New York at the Lighthouse, Inc. building and Penn Station. This stationary kiosk provides a tactile map visitors can feel to gain a sense of a space's layout. When areas of the map are touched, auditory directions are read aloud so persons who are blind can receive directions on how to access specific items within that space. A third system is the *Ping!* wayfinding system developed by Touchgraphics, Inc. (and currently being tested at the New York Hall of Science), which provides wayfinding assistance for visitors who are blind through the use of cell phone technology that visitors can use to "call" specific interactive components and activate an auditory beacon (Giusti & Landau, In press).

Conclusion

Of the areas being explored through this literature review, the universal design of information technology is perhaps the most researched and extensively explored. However, most of this research stems from areas other than museums. Whether or not the techniques used to increase access to a broader range of users in other environments are the same as those needed in a museum environment is not known. Therefore, there is still a need for substantial visitor evaluation and research in this area, particularly concerning the development of computer kiosks that meet the criteria of universal design.

Suggested resources for further reading

American Association of Museums. (1998). *Everyone's welcome*. Washington D.C.: American Association of Museums.

Association of Science-Technology Centers. (2000). *Accessible practices*. Retrieved January, 2004, from http://www.astc.org/resource/access/index.htm

Brookfield Zoo. (2002). *Every student is a scientist: Using technology to foster inclusive learning*. Retrieved October 7, 2004, from http://www.imls.gov/grants/museum/pdf/mosample.pdf

Burgstahler, S. (2002). *Real connections: Making distance learning accessible to everyone*. Retrieved October 8, 2004, from http://www.washington.edu/doit/Brochures/Technology/distance.learn.html

Chisholm, W., Vanderheiden, G., & Jacobs, I. (1999). *Web content accessibility guidelines 1.0*. Retrieved August 2003, from http://www.w3.org/TR/WAI-WEBCONTENT/

Coyne, K. P., & Nielsen, J. (2001). *Beyond ALT Text: Making the web easy to use for users with disabilities*. Fremont, CA: Nielsen Norman Group.

Coyne, K. P., & Nielsen, J. (2003). *How to conduct usability evaluations for accessibility: Methodology guidelines for testing websites and intranets with users who use assistive technology*. Fremont, CA: Nielsen Norman Group.

Davidson, B. (1991). *New dimensions for traditional dioramas: Multisensory additions for access, interest, and learning*. Boston, MA: Museum of Science.

Edwards, A. D. N. (1995). *Extra-ordinary human-computer interaction* (Vol. 7). Cambridge, UK: Cambridge University Press.

Foley, A., & Regan, B. (2003). *Best practices for web accessibility design and implementation*. San Francisco, CA: Macromedia, Inc.

Freed, G., Rothberg, M., & Wlodkowski, T. (2003). *Making educational software and web sites accessible: Design guidelines including math and science solutions*. Retrieved August 2003, from http://ncam.wgbh.org/cdrom/guideline/

Giusti, E., & Landau, S. (In press). Accessible science museums with user-activated audio beacons (working title). *Visitor Studies Today*.

Harrison, O. (2002). A great challenge and a great opportunity: student diversity and accessible information technology. *Access New England, 6*(3), 2.

Kelly, L., Savage, G., Landman, P., & Tonkin, S. (2002). *Energised, engaged and everywhere: Older Australians and museums*. Canberra, Australia: Australian Museum and the National Museum of Australia, Canberra.

Kennedy, J. (1997). *User Friendly: Hands-On Exhibits That Work*. Washington DC: Association of Science-Technology Centers, Inc.

Kirk, J. (2001, March 15-17). *Accessibility and new technology in the museum.* Paper presented at the Museums and the Web, Seattle, WA.

Lazzaro, J. J. (2001). *Adaptive technologies for learning and work environments* (2nd ed.). Chicago, IL: American Library Association.

Museum of Science Boston. (2001). *Universal Design (Accessibility)*. Retrieved December, 2003, from http://www.mos.org/exhibitdevelopment/access/

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90*(2), 312-320.

National Center for Accessible Media. (2004). *Media Access Generator (MAGpie)*. Retrieved October 8, 2004, 2004, from http://ncam.wgbh.org/webaccess/magpie/

National Center on Accessibility. (2003). *Access to play areas*. Retrieved 8/4, 2004, from http://www.ncaonline.org/playgrounds/play-areas.shtml

Plass, J. L., Chun, D. M., Mayer, R. E., & Leutner, D. (1998). Supporting visual and verbal learning preferences in a second-language multimedia-learning environment. *Journal of Educational Psychology, 90*(1), 25-36.

Rehabilitation Act, Section 508 (1998).

Reich, C. A. (2002). A survey of museums: Information technologies as tools for museum learning: Unpublished work.

Schmidt, C., & Wlodkowski, T. (2003). *A developer's guide to creating talking menus for set-top boxes and DVDs*. Retrieved August 2004, from http://ncam.wgbh.org/resources/talkingmenus/

Smithsonian Accessibility Program. (1996). *Smithsonian guide for accessible exhibition design*. Washington, D.C.: Smithsonian Institution Press.

Spry Foundation. (1999). *Older adults and the World Wide Web: a guide for web site creators* (Conference results). Washington DC: The Spry Foundation.

Stephanidis, C., & Salvendy, G. (1999). Toward an information society for all: HCI challenges and R&D recommendations. *International Journal of Human-Computer Interaction, 11*(1), 1-28.

Tate Modern. (2004). *Tate Modern Multimedia Tour*. Retrieved October 8, 2004, from http://www.tate.org.uk/modern/multimediatour/reseval.htm

Vanderheiden, G. (1994, June 15). Application software design guidelines: Increasing the accessibility of application software to people with disabilities and older users. Retrieved October 8, 2004, from http://trace.wisc.edu/docs/software_guidelines/software.htm

Question 4: Using audio as an interpretive tool to broaden access to learning in museums

In recent years, a number of institutions have included audio interpretation in their exhibitions as a means of increasing access to interpretative and instructional information for visitors who are blind. Notable science center examples include the Museum of Science, the Science Museum of Minnesota and the New York Hall of Science. While the work conducted at the Museum of Science and the Science Museum of Minnesota has not been extensively studied, the New York Hall of Science has made considerable effort to conduct visitor research related to the effectiveness of their audio tours (Friedman, 2000). The New York Hall of Science plans to continue their work in this area over the next few years, including a pilot study that is currently underway of the *Ping!* wayfinding system developed by Touchgraphics, Inc., which provides wayfinding assistance for visitors who are blind through the use of cell phone technology that visitors can use to “call” specific interactive components and activate an auditory beacon (Friedman, 2000; Giusti & Landau, In press). While the New York Hall of Science’s work in this area is noteworthy and extensive, it focuses specifically on providing access to visitors who are blind, and is therefore a study of an accessible, and not universal, design feature of museum exhibitions.

Results from previously conducted visitor studies have shown that simply providing auditory information is not sufficient for providing full access to learning for visitors who are blind in museums. Summative evaluation findings from the New York Hall of Science’s audio tour found that the tour was most successful when it was used to accompany an exhibition that utilized both tactile and auditory means to facilitate learning. This finding corresponds to the results of a survey conducted by the Royal National Institute of the Blind (RNIB), which found that persons who are blind were more likely to list touchable displays and objects and sighted guides as “helpful” or “very helpful” than any of the other interpretive mediums listed (Hillis, 2003). This survey also found that persons who are blind were more likely to list audio as helpful or very helpful as compared to Braille, which suggests that audio might be the better medium for interpreting the tactile or auditory learning experiences provided in a museum exhibition.

While there have been a number of studies that address the use of audio to deliver information to visitors who are blind, few, if any, visitor studies have explored the use of audio to assist visitors with reading-related learning disabilities or other cognitive impairments. This is an area that could benefit from further study.

Auditory learning in settings other than museums

The field of multimedia learning has produced a number of recent resources that provide information on auditory learning for persons who are blind. In particular, the National Center for Accessible Media has conducted studies and developed guidelines related to the creation of talking menus for DVDs (Schmidt & Wlodkowski, 2003), audio descriptions for documentaries or other educational video presentations (National Center for Accessible Media, 2004), and audio interpretation of educational software (Freed et al., 2003). These publications provide useful information about how to structure the delivery of auditory information based on differences between the ways the human brain processes auditory versus visual information. Suggested guidelines include limiting the number of available choices and thinking critically about the order of the information delivered so that it decreases the burden placed on an individual's auditory working memory.

Much of the formal education literature focuses on the effectiveness of read-aloud accommodations provided for students with certain disabilities that are required to take standardized testing. Students provided with read-aloud accommodation include those with a visual impairment, learning disability, cognitive disability, emotional/behavioral disability, and communication disability. Research has demonstrated that this accommodation generally has a positive effect on test scores of students with disabilities (Thompson, Blount, & Thurlow, 2002). Students with a variety of mild disabilities also show greater improvement in knowledge-acquisition when using an audio textbook in place of independent textbook reading (Banerjee et al., 2003).

Although not specifically addressing the needs of persons with disabilities, research conducted by Mayer and Moreno found that the addition of audio to visually presented information can increase learning for students without disabilities. In their study, students were better able to recall information and apply it to solve a problem when visual (pictorial) information was accompanied by audio rather than textual information (Mayer & Moreno, 1998). This suggests that all learners may potentially benefit from audio information accompanying visual displays.

Suggested resources for further reading

Banerjee, M., Brinckerhoff, L. C., Washburn, S. G., Connelly, V. J., Rosenberg, M. S., & Boyle, E. A. (2003). Effects of audio texts on acquisition of secondary-level content by students with mild disabilities. *Learning Disability Quarterly, 26*(3), 203-214.

Freed, G., Rothberg, M., & Wlodkowski, T. (2003). *Making educational software and web sites accessible: Design guidelines including math and science solutions*. Retrieved August, 2003, from http://ncam.wgbh.org/cdrom/guideline/

Friedman, A. J. (2000). Expanding audiences: the audio tour access project at the New York Hall of Science. *Dimensions*, 7-8.

Giusti, E., & Landau, S. (In press). Accessible science museums with user-activated audio beacons (working title). *Visitor Studies Today*.

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90*(2), 312-320.

National Center for Accessible Media. (2004). *Media Access Generator (MAGpie)*. Retrieved October 8, 2004, 2004, from http://ncam.wgbh.org/webaccess/magpie/

Schmidt, C., & Wlodkowski, T. (2003). *A developer's guide to creating talking menus for set-top boxes and DVDs*. Retrieved August 2004, from http://ncam.wgbh.org/resources/talkingmenus/

Thompson, S. J., Blount, A., & Thurlow, M. (2002). *A summary of research on the effects of test accommodations: 1999 through 2001 (Technical Report 34)*. Minneapolis, MN: University of Minnesota, National Center on Educational Outcomes.

Question 5: Using diagrams, drawings or photos to broaden access to exhibit labels

Review of the literature did not reveal any visitor evaluation or research studies that have examined the effectiveness of using images on exhibit labels to create exhibit instructions and interpretations that are more accessible for visitors with disabilities. While a few museums in Europe have attempted to use images to convey meaning to a museum audience that speaks multiple languages (such as the Heureka science center in Finland), and others have attempted to create visual instructions for visitors with disabilities (such as the Discovery Center Museum in Rockford, IL), the impact of using these images were not studied. However, guidelines developed by non-museum researchers for the most effective use of color for persons with partial sight or congenital color deficits can be directly applied to the design of visual displays such as exhibit labels (Arditi, 1997).

Audiences who might benefit from the use of images on exhibit labels

The use of images for exhibit instructions and interpretation could potentially benefit multiple audiences for whom traditional English text labels are currently inaccessible, including visitors who are Deaf and use American Sign Language, visitors who speak English as a second language or non-English speakers, young children, and visitors with learning or developmental disabilities. Some psychologists also believe that learners can be categorized as either “visualizers” or “verbalizers,” thus suggesting that a segment of the museum audience that does not identify as having a disability might also benefit from the use of images on exhibit labels (J. L. Plass, D. M. Chun, R. E. Mayer, & D. Leutner, 1998).

The use of images to provide instruction is a practice commonly used by teachers who work with students who have developmental disabilities, such as autism and down syndrome (Maraj, Li, Hillman, Jeansonne, & Ringenbach, 2003; Quill, 1997; Sandoz, 2003). When working with students who have autism, particularly those considered to be “visual learners,” practitioners use a visual systems to provide detailed step-by-step guidance on how to complete a given task. In some cases, the system consists of a series of images, broken down into discreet steps students can mimic to determine what they are supposed to do. In other cases, graphics are pointed to and addressed as the instructor is talking to help the student form connections between the image and the spoken word (Quill, 1997). Photographs are commonly used for both systems since they are concrete representations of the tasks and materials (Quill, 1995). Some evidence suggests, however, that line drawings might be more effective than photographs**.** Although line drawings are a more abstract representation, they have two benefits over photographs: they allow for greater contrast between the background and the foreground, and they reduce “visual noise” and therefore may help the learner to focus his or her attention on the details that are most important for completing the task (Quill, 1995).

Some disability studies scholars theorize that students with learning disabilities such as dyslexia may, in general, be better at visual thinking than students who are not identified as “learning disabled” (West, 1997). While this theory has not yet been proven, many educators advocate for the use of graphic organizers to help the students with learning disabilities focus their attention on important concepts and ideas, and organize their thoughts about the relationship between one concept and another (Ellis, 1994). This graphic presentation of information differs greatly from the images used to educate children with autism, as it focuses on the organization of text, and not the presentation of images to convey meaning.

Visitors who speak English as a second language might also find the addition of images to label copy to be helpful. According to research conducted in the field of second language learning, people who are multilingual imagine the same image whenever they speak or read a word, regardless of the language they are using at the time (Paivio, 1986). For example, a person who speaks Spanish, Turkish and English will picture in their mind the same cat regardless of whether they read the term “gato” or “kedi” or “cat.” The simultaneous use of images and text has also been found to assist second language learners as they acquire new vocabulary. Students who were exposed to image and word translations of foreign words scored higher on vocabulary recall and understanding tests than those who were only given word translations (Jan L. Plass et al., 1998).

Educators in Australia have found images to be a useful tool for providing translations of scientific terms and ideas into “Plain English.” They have been exploring the use of an abstract picture language to teach scientific concepts to middle school students, hoping that they images can bridge students’ conceptions about energy and change to the complex language and vocabulary of science. Evaluations conducted of programs utilizing this technique found that the students were able to learn the language portrayed by the images, and utilize the abstract drawings to later recall ideas and concepts about energy and change (Stylianidou & Boohan, 1999).

Who doesn't benefit

There are many visitor groups who would not be able to use images to understand instructions or interpretations of exhibit interactives, such as visitors with certain types of learning disabilities, certain types of autism (some persons with autism are not able to process visual information), and visitors who are blind or have low vision. Guidelines and standards discussing the universal design of websites and other computer software make little reference to how images should be designed to maximize content understanding by persons with disabilities (Burgstahler, 2002; Chisholm et al., 1999; Kara P. Coyne & Nielsen, 2001; Foley & Regan, 2003; Freed et al., 2003; "Rehabilitation Act," 1998; Schmidt & Wlodkowski, 2003; Spry Foundation, 1999; Vanderheider, 1994). These guidelines do discuss, however, ways to provide access to the content contained in images to persons with low vision (through the use of high contrast line drawings) or to persons who are blind (through the use of audio description). Additionally, some literature discusses the use of tactile line drawings or graphics that can be used by persons who are blind to understand information portrayed in a visual image or graphic. "Tactile Graphics" is an exemplary book published by the American Foundation for the Blind that provides more information on this topic (Edman, 1992).

Audiences who would have difficulty accessing or understanding information conveyed through images benefit most from the use of audio and tactile modes of interpretation. A possible topic that could be explored is the combined use of audio and images to provide a more universal approach to exhibit interpretation. Combining audio and images has been found to be beneficial in the instruction of college students who were not identified as having a disability (Jan L. Plass et al., 1998).

Universal pictorial languages

Many people have sought to create of a pictorial language that could provide universal understanding of ideas and concepts for individuals speaking a wide variety of languages. Despite these efforts, there does not seem to be any research that supports the idea that such a language does, or could, exist. Some psychologists believe that images could not replace the use of written or spoken language as unlike language, images do not have syntax and often have arbitrary interpretations (Rose & Meyer, 2002). Therefore, these psychologies believe that images could never be used in place of language, but could be used effectively to enhance written or spoken interpretation.

Suggested resources for further reading

Edman, P. K. (1992). *Tactile graphics*. New York, NY: American Foundation for the Blind.

Ellis, E. S. (1994). Integrating writing strategy instruction with content-area instruction: Part I. *Intervention in School & Clinic, 29*(3), 169-180.

Maraj, B. K. V., Li, L., Hillman, R., Jeansonne, J. J., & Ringenbach, S. D. (2003). Verbal and visual instruction in motor skill acquisition forpersons with and without down syndrome. *Adapted Physical Activity Quarterly, 20*(1), 57-70.

Paivio, A. (1986). *Mental Representations: A Dual Coding Approach* (Vol. 9). New York, NY: Oxford University Press.

Plass, J. L., Chun, D. M., Mayer, R. E., & Leutner, D. (1998). Supporting visual and verbal learning preferences in a second-language multimedia learning environment. *Journal of Educational Psychology, 90*(1), 25-36.

Quill, K. A. (1995). Visually cued instruction for children with autism and pervasive developmental disorders. *Focus on Autistic Behavior, 10*(3), 10-20.

Quill, K. A. (1997). Instructional considerations for young children with autism: The rationale for visually cued instruction. *Journal of Autism and Developmental Disorders, 27*(6), 697-714.

Rose, D. H., & Meyer, A. (2002). *Teaching every student in the digital age: Universal design for learning*. Alexandria, VA: Association for Supervision and Curriculum Development.

Sandoz, J. (2003, February 20-21). *Reasonable accommidation in training safety*. Paper presented at the Annual Meeting of the Louisiana Educational Research Association.

Stylianidou, F., & Boohan, R. (1999, March 28-31). *Pupils reasoning about the nature of change using an abstract picture language.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA.

West, T. G. (1997). *In the Mind's Eye: Visual thinkers, gifted people with dyslexia and other learning difficulties, computer images and the ironies of creativity*. Amherst, NY: Prometheus Books.

Question 6: Best practices for including people with disabilities in research/ evaluation studies

The concept of universal design represents a relationship between the designed environment and the functional abilities of its users and occupants. For this reason, the participatory design process, where the actual users are considered experts and are actively solicited for feedback during a design's creation, is advocated as a means for achieving universal design (Ringaert, 2001; Wright, 2003). Practitioners of participatory design utilize a variety of research methods, such as ethnographic observations, user interviews and focus groups (Kensing & Blomberg, 1998; Kensing, Simonsen, & Bodker, 1998; Sperschneider & Bagger, 2003), all of which are commonly used in the evaluation of museum exhibitions. Another framework frequently used for research and evaluation studies pertaining to universal design is to focus on the defects of the environment, and not the "defects" of the possible users when assessing who is able or unable to fully participate in a given environment (Gill, 1999; Mertens, 1999).

To date, very few research studies have been conducted in the area of universal design. Therefore, few standardized instruments or methodologies exist for studying universal design. In 1998, an international forum was held in Greece titled "Towards an Information Society for All." During this meeting, researchers from around the globe met to set an agenda for creating human-computer interactions that met the needs of diverse learners. One of the key findings from this meeting was the need to develop effective user testing methods that meet the needs of diverse users with varying abilities. As stated in the conference report,

> *User involvement in the design of computer-based interactive systems has long been a challenging issue. Despite its potential value, it needs to be carefully*

> *planned and assessed in different phases of a product's life cycle. Participatory design has provided useful insights into how user involvement might be managed in practice and offers several tools and guiding principles. However, the existing wisdom offers very little in the direction of involving different user groups with diverse abilities, skills, requirements, and preferences. Therefore, actions should be undertaken to refine and extend the available instruments so that they can effectively guide the design of new computer-mediated human activities (Stephanidis & Salvendy, 1999).*

Following publication of the workshop proceedings, at least one publication has been produced which addresses ways to involve users with diverse abilities and background in user testing (Kara Pernice Coyne & Nielsen, 2003). However, the absence of information related to this topic is still significant, and is a possible area that can be explored through the multi-institutional research project.

Universal design should be considered more a process than an achievable goal. Therefore, measuring whether a design is successful at providing access for persons of a wide range of abilities and disabilities is a difficult endeavor. Two examples of studies that attempted to measure the universality of a given design is the study of the Lighthouse, Inc. building in New York City (Danford, 2003), and a study of a standardized test that had been modified to increase access for persons with disabilities (Thompson, Johnstone, & Thurlow, 2002). Methods used in these studies could be applied when studying universal design in museums. To measure whether the Lighthouse, Inc. building was a "universal design", abled-bodied and disabled participants were asked to complete a series of tasks as a way of measuring the ease of which they were able to navigate their way through a building. Following the completion of these tasks, the participants were also asked to compare the relative ease of which they navigated the Lighthouse, Inc. building as compared with others. In the standardized test study, a test was modified following the principles of universal design. These modifications made the test easier to use for students with certain disabilities, but did not impact the level of difficulty or the content of the concepts being tested. Students with and without disabilities were tested using these two tests and the scores compared.

Another possibility for research instruments that could be applied to the study of universal design in museum exhibitions are two questionnaires created by the Center for Universal Design in North Carolina for use by designers and consumers (Center for Universal Design, 2003). It was intended that an individual would use this questionnaire to determine if a product they are designing or buying might be considered a universal design. These questionnaires were not created as a way to collect data from a wide variety of users as part of a research study. There may be, however, ways these questionnaires could be adapted and used to collect data from visitors of a broad range of abilities and disabilities to gather information about the user's perception of the usability of a museum exhibition, or individual interactive.

Suggested resources for further reading

Center for Universal Design. (2003). *A guide to evaluating the universal design performance of products*. Retrieved October 8, 2004, from http://www.design.ncsu.edu/cud/events_news/UD_Performance.html

Coyne, K. P., & Nielsen, J. (2003). *How to conduct usability evaluations for accessibility: Methodology guidelines for testing websites and intranets with users who use assistive technology*. Fremont, CA: Nielsen Norman Group.

Danford, G. S. (2003). Universal Design: People with vision, hearing and mobility impairments evaluate a model building. *Generations, 27*(1), 91-95.

Gill, C. J. (1999). Invisible ubiquity: The surprising relevance of disability issues in evaluation. *American Journal of Evaluation*, *20*(2), 279-289.

Johnstone, C. J. (2003). *Improving validity of large-scale tests: Universal design and student performance (Technical Report 37)*. Minneapolis, MN: University of Minnesota, National Center for Educational Outcomes.

Kensing, F., & Blomberg, J. (1998). Participatory design: issues and concerns. *Computer Supported Cooperative Work, 7*, 167-185.

Kensing, F., Simonsen, J., & Bodker, K. (1998). MUST: A method for participatory design. *Human-Computer Interaction, 13,* 167-198.

Mertens, D. M. (1999). Inclusive evaluation: Implications for transformative theory for evaluation. *American Journal of Evaluation*, *20*(1).

Ringaert, L. (2001). User/ expert involvement in universal design. In W. F. E. Preiser & E. Ostroff (Eds.), *Universal Design Handbook* (pp. 6.1-6.14). New York, NY: McGraw-Hill.

Sperschneider, W., & Bagger, K. (2003). Ethnographic fieldwork under industrial constraints: Toward design in context. *International Journal of Human-Computer Interaction, 15*(1), 41-50.

Stephanidis, C., & Salvendy, G. (1999). Toward an information society for all: HCI challenges and R&D recommendations. *International Journal of Human-Computer Interaction, 11*(1), 1-28.

Thompson, S. J., Johnstone, C. J., & Thurlow, M. L. (2002). *Universal design applied to large-scale assessments (Synthesis Report 44).* Minneapolis, MN: University of Minnesota, National Center on Educational Outcomes.

Wright, E. (2003). Designing for an ageing population: an inclusive design methodology. *Art, Design and Communication in Higher Education*, *2*(3), 155-165.

Question 7: Universal design and early childhood spaces

The literature relating to designing or modifying early childhood spaces for children with disabilities generally focuses on one of two areas: ensuring that a space is Americans with Disability Act (ADA) or Individuals with Disabilities Education Act (IDEA) compliant or modifying a space for a child with a specific disability. The requirements put forth by the ADA and IDEA emphasize the inclusion of children with disabilities in public spaces or school classrooms, but the focus of literature seems to be mainly on physical inclusion, with social or cognitive inclusion mentioned only occasionally and as a secondary consideration.

Much of the literature relating to educational spaces for young children focuses on the planning and design of educational facilities to be physically accessible for children with disabilities and Individuals with Disabilities Education Act (IDEA) compliant (Abend, 2001). There are also suggestions for modifications to early childhood classrooms for children with special needs in order to actively engage all children in a classroom setting, focusing both on physical and cognitive inclusion. These suggestions tend to focus on modifications based on specific disabilities, including developmental delays, autism, Attention Deficit Hyperactivity Disorder, or visual problems (Gould & Sullivan, 1999; Zionts, 1997). Best practices for the effective inclusion of children with disabilities in classrooms are being discussed and reviewed for children of all ages (Zionts, 1997).

A great body of literature exists detailing requirements and guidelines for play areas. *The Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Play Areas* provide the detailed legal requirements for play areas, including those in child care facilities, amusement attractions, and water play areas. The rules focus on the physical requirements for play areas, and emphasize accessibility and inclusion for children with disabilities ("Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Play Areas," 2000). Guidelines relating to play areas for young children offer advice on the design of specific playground components, such as slides, swings, rockers, and climbing areas (Burkhour, 2003; National Center on Accessibility, 2003). Detailed guidelines also exist for a wide variety of specific components in play areas for children, including entrances, pathways, ground covers, vegetation, water, and sand settings. These guidelines focus primarily on physical safety and accessibility, with some brief mention of social as well as physical inclusion (Moore, Goltsman, & Iacofano, 1992). A number of organizations also provide advice on how to create specific categories of play spaces accessible for children with certain disabilities, such as Forever Young Treehouses Inc. in Vermont (Machalaba, 2003) or Northeast Passage, a University of New Hampshire-based outdoor recreation program for people with disabilities (Goldberg, 2000). These advocacy groups tend to emphasize both physical and social inclusion for children with disabilities.

Suggested resources for further reading

Abend, A. C. (2001). *Planning and designing for students with disabilities*. Washington D. C.: National Clearinghouse for Educational Facilities.

Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Play Areas, (2000).

Burkhour, C. (2003). *Playgrounds for ALL kids!* Retrieved 8/4, 2004, from http://www.ncaonline.org/ncpad/play4all.shtml

Goldberg, C. (2000, August 17). For these trailblazers, wheelchairs matter. *New York Times,* p. A1.

Gould, P., & Sullivan, J. (1999). *The inclusive early childhood classroom*. Beltsville, MD: Gryphon House.

Machalaba, D. (2003). A dream takes root: Treehouses for kids with disabilities. *The Wall Street Journal*.

Moore, R., Goltsman, S., & Iacofano, E. (Eds.). (1992). *Play for all guidelines: Planning, design and management of outdoor play settings for all children*. Berkeley, CA: MIG Communications.

National Center on Accessibility. (2003). *Access to play areas*. Retrieved 8/4, 2004, from http://www.ncaonline.org/playgrounds/play-areas.shtml

Zionts, P. (Ed.). (1997). *Inclusion strategies for students with learning and behavior problems: Perspectives, experiences, and best practices*. Austin, TX: Pro-Ed.

Question 8: Universal design of science laboratories

Much of the published literature regarding the development of accessible laboratories is from the field of formal learning, and focuses on the inclusion of disabled students in high school and university laboratories. This literature provides suggestions and guidelines for the physical modifications of the laboratory spaces, teaching methods, and lab activities to fit the needs of a student with a specific disability. Published articles related to the accessibility of science laboratories are mostly guidelines and standards developed by committees and science education professionals. None of the located articles present the results of user or other research studies that examine the accessibility or universal design of laboratory spaces.

The most comprehensive guidelines for developing accessible laboratory spaces was developed by the American Chemical Society Committee on Chemists with Disabilities. This detailed manual provides guidelines on laws and services, laboratory settings, and universal design in science education (Miner, Nieman, Swanson, & Woods, 2001). Other sources, detailed below, provide more specific guidelines and suggestions for lab spaces, teaching methods, and lab activities.

Within the published guidelines listed below, museums interested in producing accessible or universally designed science laboratories can find information about the safety and inclusion of students with disabilities in laboratory learning. These guidelines provide specific information about the height of lab tables and fume hoods, aisle width, drawers, face shields, and safety showers. Published guidelines also present ideas for modifying the lab equipment itself such as measuring devices (thermometers, rulers, balances, etc.), Bunsen burners, Braille or color-coded labels, and tactile drawings or graphs (DO-IT AccessSTEM, 2001; Miner et al., 2001).

The literature suggests that teaching strategies in laboratories should also be modified to allow all students cognitive access to the subject matter. Some sources focus on suggestions for teaching style modifications based on the disabilities of individual student, including attention deficit, learning disorders, behavioral disorders, hearing impairment, or visual impairment (Keller, 2002). More general teaching strategies are also provided, such as using multiple means of expression, representation, and engagement (McDaniel, Wolf, Mahaffy, & Teggins, 1994) or simplifying vocabulary, text, and instructional delivery (Kahn, 2003).

Guidelines created by the DO-IT center at the University of Washington and the organization Science Education for Students with Disabilities provide information on modifications that can be made to lab activities that improve access for students with blindness, low vision, mobility impairments, hearing impairments, emotional disabilities, and learning disabilities (DO-IT AccessSTEM, 2001; Kahn, 2003). These sources focus on both physical and intellectual inclusion of students with disabilities. Suggestions for modifications in science laboratory courses can be found for the collegiate level as well, with the emphasis on developing and using a methodology that promotes inclusion of all students in laboratory courses and encouraging them to explore careers in the sciences (McDaniel et al., 1994).

Suggested resources for further reading

DO-IT AccessSTEM. (2001). *Science labs*. Retrieved 8/5, 2004, from http://www.washington.edu/doit/Stem/science.html

Keller, E. (2002). *Disabilities, teaching strategies, and resources*. Retrieved 8/24, 2004, from http://www.as.wvu.edu/~scidis/sitemap.html

Kahn, S. (2003). Including all students in hands-on learning. *ENC Focus, 10*(2), 14-17.

McDaniel, N., Wolf, G., Mahaffy, C., & Teggins, J. (1994). Inclusion of students with disabilities in a college chemistry laboratory course. *Journal of Postsecondary Education and Disability*, *11*(1), 20-28.

Miner, D. L., Nieman, R., Swanson, A. B., & Woods, M. (Eds.). (2001). *Teaching chemistry to students with disabilities: A manual for high schools, colleges, and graduate programs* (4th ed.): American Chemical Society.

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American Association of Museums. (1998). *Everyone's welcome*. Washington D.C.: American Association of Museums.

Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Play Areas, (2000).

Arditi, A. (1997). *Effective Color Contrast*. Retrieved 2/14, 2005, from http://www.lighthouse.org/color_contrast.htm

Association of Science-Technology Centers. (2000). *Accessible practices*. Retrieved January, 2004, from http://www.astc.org/resource/access/index.htm

Banerjee, M., Brinckerhoff, L. C., Washburn, S. G., Connelly, V. J., Rosenberg, M. S., & Boyle, E. A. (2003). Effects of audio texts on acquisition of secondary-level content by students with mild disabilities. *Learning Disability Quarterly, 26*(3), 203-214.

Blamires, M. (1999). Universal design for learning: re-establishing differentiation as part of the inclusion agenda? *Support for Learning, 14*(4), 158-163.

Bowe, F. G. (2000). *Universal design in education: Teaching nontraditional students*. Westport, CT: Bergin and Garvey.

Brookfield Zoo. (2002). *Every student is a scientist: Using technology to foster inclusive learning*. Retrieved October 7, 2004, from http://www.imls.gov/grants/museum/pdf/mosample.pdf

Burgstahler, S. (2002). *Real connections: Making distance learning accessible to everyone*. Retrieved October 8, 2004, from http://www.washington.edu/doit/Brochures/Technology/distance.learn.html

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