Inclusion, Disabilities, and Informal Science Learning

A CAISE Inquiry Group Report

March 2010

About CAISE

The Center for Advancement of Informal Science Education (CAISE) works to strengthen and connect the informal science education community by catalyzing conversation and collaboration across the entire field—including film and broadcast media, science centers and museums, zoos and aquariums, botanical gardens and nature centers, digital media and gaming, science journalism, and youth, community, and after-school programs. CAISE focuses on improving practice, documenting evidence of impact, and communicating the contributions of informal science education.

Founded in 2007 with support from the National Science Foundation (NSF), CAISE is a partnership among the Association of Science-Technology Centers (ASTC), Oregon State University (OSU), the University of Pittsburgh Center for Learning in Out-of-School Environments (UPCLOSE), and the Visitor Studies Association (VSA). Inverness Research Associates serves as evaluator. CAISE is housed at ASTC's Washington, D.C. offices.

For more information contact:

Center for Advancement of Informal Science Education
1025 Vermont Avenue NW, Suite 500
Washington, DC 20005-6310
202/783-7200
www.insci.org

Citation:
Reich, C., Price, J., Rubin, E., Steiner, M. 2010. Inclusion, Disabilities, and Informal Science Learning. A CAISE Inquiry Group Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE).

Inclusion, Disabilities, and Informal Science Learning

CAISE Access Inquiry Group Participants

Christine Reich*	Manager, Research and Evaluation, Museum of Science, Boston
Jeremy Price	Doctoral Student, Science and Technology program, Department of Curriculum and Instruction, Lynch School of Education at Boston College
Ellen Rubin	Independent Consultant, New York City
Mary Ann Steiner	Graduate Researcher, University of Pittsburgh Center for Learning in Out-of-School Environments, Learning Research and Development Center, Pittsburgh

Center for Advancement of Informal Science Education (CAISE) Washington, D.C. March 2010

*Corresponding author (creich@mos.org)

This material is based upon work supported by the National Science Foundation under Grant No. DRL-0638981. Any opinions, findings, and conclusions, expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the Center for Advancement of Informal Science Education.

Contents

Foreword

This report is the result of work over the last year by the Center for Advancement of Informal Science Education (CAISE) Access Inquiry Group (CAISE AIG). The group was constituted in 2008 as part of an effort to broaden participation in informal science education.

We are deeply grateful to Christine Reich, Jeremy Price, Ellen Rubin, and Mary Ann Steiner for leading this inquiry and authoring the report. Each brings significant personal and professional expertise to this work (see page 8). In addition, the group drew on the advice of their extensive networks of informal science education (ISE) and disabilities professionals. They solicited input through a session at the July 2008 Informal Science Education Summit in Washington, D.C., organized by CAISE; through notices on the Informal Science Education (ISEN-ASTC-L) e-mail list; through direct contacts with colleagues; and in other ways. They also made a special effort to review results of projects funded by the National Science Foundation (NSF); these are identified by award number. They met at least once a month for a year to discuss their findings and briefed NSF officials as they completed data-gathering and analysis to solicit feedback.

Based on this work, they present their findings and identify opportunities with three audiences in mind: principal investigators (PIs) and prospective PIs of projects funded by NSF's Informal Science Education (ISE) program; NSF ISE program officers and other funders; the informal science education (ISE) field as a whole.

Their report includes practical knowledge that can be put to work and evidence of the contributions of ISE. It also identifies areas where the authors believe more work and investment are needed. Following an introduction, which provides a conceptual framework for thinking about inclusion of people with disabilities in ISE, the report addresses three areas of ISE: museums, broadly defined; media and technology; and youth and community programs. There is some overlap in the three accounts, as in the actual experiences they describe: museums run youth and community programs, for example; media and technology can be used as interactive or instructional supports within an exhibition or program; and websites may be based on content originally developed for out-of-school programs or museum exhibitions.

But the three accounts also differ. Christine Reich, author of the chapter on museums, draws from her experience as a former exhibit developer and, now, evaluator and visitor studies researcher. Jeremy Price and Mary Ann Steiner, authors of the chapter on media and technology, suggest possibilities for the use of media and technology for inclusion, drawing on Jeremy's experiences with universal design at CAST and the WGBH National Center for Accessible Media and Mary Ann's with youth and technology at the Science Museum of Minnesota and elsewhere. Ellen Rubin, former consultant to the NSF-funded Accessible Museum Practices Program, draws on a lifetime of personal experience and reflection in her chapter on youth and community programs.

The discussions that began among the members of the CAISE AIG are intended to inform and spark further study, discussion, and reflection among colleagues from across the field. We look forward to continuing the conversation. To find out about online discussions and conference sessions, visit the CAISE website (www.insci.org), join the CAISE Forum (at www.connect.astc.org) and subscribe to the CAISE Newsletter.

We are grateful to the National Science Foundation for its support of CAISE and informal science education field.

Wendy Pollock, Principal Investigator, CAISE

CAISE Access Inquiry Group Participants

Jeremy Price is currently a doctoral student in the Science and Technology program of the Department of Curriculum and Instruction at the Lynch School of Education at Boston College, where he has been a part of the team to develop, research, and evaluate a high school urban ecology curriculum in partnership with the Urban Ecology Institute at Boston College. He has worked as Media and Technology Specialist for CAST, designing inclusive technology-based learning environments based on the principles of Universal Design for Learning. Earlier, he served as the Education Technology Coordinator at the Natural History Museum of Los Angeles County, where he oversaw the design and creation of technology-based components of exhibits and educational programs in the exhibit halls, in mobile education programs, and on the World Wide Web. He has also worked as an intern with the National Center for Accessible Media at WGBH. Jeremy holds a B.A. in anthropology from Brandeis University and an Ed.M. from the Harvard Graduate School of Education.

Christine Reich, manager of research and evaluation at the Museum of Science, Boston, since 1997, oversees studies of various aspects of the museum experience, including visitor services, exhibitions, school field trip programs, teacher professional development, adult programs, and educational technologies. Earlier, as museum educator and exhibit planner, she worked on exhibitions such the NSF-funded exhibitions *Secrets of Aging*, which targeted older adult and intergenerational audiences; and *Making Models*, which engaged visitors with a broad range of abilities in the science inquiry process. She is chair-elect of the Committee for Audience Research and Evaluation, a Standing Professional Committee of the American Association of Museums. Ms. Reich has a B.S. in agricultural and biological engineering from Cornell University, a C.M.S. from Harvard University in museum studies, and an M.Ed. from Lesley University in museum education. She is currently working on her Ph.D. in curriculum and instruction at Boston College.

Ellen Rubin is an independent consultant based in New York City. During 20 years at Educational Equity Concepts (EEC), Rubin helped to create practical, hands-on, bias-free materials and programs with a focus on science and disability for early childhood and elementary classrooms. Ellen has been a guest lecturer at colleges and universities in the New York area, speaking about the importance of preparing students with disabilities to fully participate in their communities. She is author or co-author of a number of publications, including "You Don't Have to Be Sighted to be a Scientist, Do You?", *Bridging the Gap: A National Directory of Services for Women and Girls with Disabilities*, and "Connecting Gender and Disability." Rubin has served as a consultant on access for people with disabilities to a number of cultural institutions, among them New York City's Lincoln Center for the Performing Arts, Wildlife Conservation Society, Touch Graphics, Inc., and the Association of Science-Technology Centers. She has a Master's degree in special education from Bank Street College of Education and has taught children and adults with a wide range of disabilities.

Mary Ann Steiner is a graduate researcher in the University of Pittsburgh Center for Learning in Out-of-School Environments (UPCLOSE) and the Learning Sciences and Policy Program. Her career has been shaped by 18 years at the Science Museum of Minnesota, establishing and running a center where teens develop and present informal science experiences to public audiences in the museum and neighborhood settings (see http://www.smm.org/about/kaysc). Her Master's program field study took her to Northern Ireland to help to establish museum-based youth programs. She completed a two-year rotation at the National Science Foundation as a program officer for the Informal Science Education program bringing her program design experience to the foundation's interest in reaching under-represented audiences, understanding how to scale and replicate programs and pushing the field in terms understanding impacts through evaluation and research. These experiences with practice and policy have led to her current research interest in the role that content-rich community resources can play in supporting community learning for people of all ages, and the ways community knowledge can inform the work of these same institutions. She has participated in several robotics technology outreach and research projects looking at how communities adapt university ideas to local purposes to better understand how publics and institutions can cultivate and sustain rich learning ecologies in local communities.

Acknowledgments

We would like to thank the following individuals, who provided leads and reviewed drafts of this report. We also thank Terri Gipson of CAISE for research assistance, Christine Ruffo of ASTC for report design and layout, and Wendy Pollock for her contributions including editing of this report.

Betty Davidson
Exhibit planner/consultant

Nell Brady
WAMC Northeast Public Radio

Sheryl Burgstahler
DO-IT (Disabilities, Opportunities, Internetworking, and Technology)
University of Washington

Glen Busby
WAMC Northeast Public Radio

Jason Freeman
Consutant on After-School Science

Cecilia Garibay
Garibay Group

Mindy Johnson
CAST

J. Shipley Newlin
Science Museum of Minnesota

Terrie Nolinske
TNI Consultants

Vrylena Olney
Nanoscale Informal Science Education Network

Rae Ostman
Sciencenter, Ithaca, New York

Madeleine Rothberg
WGBH

Matthew H. Schneps
Harvard-Smithsonian Center for Astrophysics

Orrin Shane
National Science Foundation

Mary M. Shea
Kids Included Together project consultant

Jo-Ann Sowers
Portland State University

Maryann Stimmer
Educational Equity Center

Kate Taylor
WGBH

Beth Ziebarth
Smithsonian Institution

While we have benefited greatly from the support and input of others, the final content of this report, including any errors, is the responsibility of the authors, and does not necessarily reflect the views of the Center for Advancement of Informal Science Education or the National Science Foundation. This material is based upon work supported by the National Science Foundation under grant No. DRL-0638981.

Christine Reich
Jeremy Price
Ellen Rubin
Mary Ann Steiner

March 2010

Executive Summary

Informal science education (ISE) experiences can provide powerful opportunities for people with disabilities to experience and learn about science. When designed to be inclusive, such experiences can lead people with disabilities to feel competent and empowered as science learners, generate excitement and enthusiasm for science, and be equitable learning experiences that promote learning for all. When such design considerations are not taken into account, however, the result can be feelings of disempowerment, frustration, discomfort, and alienation from science.

This report provides a summary of the investigations and inquiries of the Center for the Advancement of Informal Science Education Access Inquiry Group (CAISE AIG), which was commissioned in 2008 to survey the ISE field in order to answer the following questions:

1) In what ways has the ISE field worked to include people with disabilities in informal science learning?

2) What does prior work tell us about actions that should be taken in the future?

The group explored current practices of ISE professionals that promote the inclusion of people with disabilities in informal science learning and then developed a framework for refining future practices. The resulting report is intended for funders of informal science learning programs, future proposal writers, peer reviewers, evaluators, and professionals who design and implement ISE programs, exhibits, and technologies. It also addresses the multiple venues through which informal science experiences are provided, including science museums, youth and community programs, and media and technology.

A framework for inclusion

According to the social model of disability, inclusion is more than simply gaining access into a physical structure—it is also about gaining equal access to the policies, practices, and systems that civil society affords (Barnes, 2003). Inclusion in ISE, therefore, goes further than ensuring that people with disabilities can enter the buildings or use the exhibits, programs, and technologies that deliver such experiences. It also requires that people with disabilities be able to learn from such experiences and participate as a part of, and not separate from, the larger social group and community. Similar to definitions of inclusion from the field of formal education (Blamires, 1999), inclusion in ISE experiences has physical, cognitive, and social dimensions. Inclusion in ISE requires that learners be able to:

> **Physically interact with/perceive the space**—Key design questions include: Is the space set up so that a diversity of individuals can move around the space comfortably and safely? Is the information in the space conveyed in a variety of formats so that a diversity of individuals can perceive it? Can a diversity of individuals manipulate or cause things to happen within in the space?
>
> **Cognitively engage with the materials**—Key design questions include: Is the information conveyed using a range of media to allow a diversity of individuals to engage with the materials? Do the materials take into account a diversity of individuals with a range of learning and cognitive skills? Do the materials take into account a diversity of individuals with ranges of experiences and sets of background knowledge?
>
> **Socially interact with one another**—Key design questions include: Is the environment generally safe and welcoming for a diversity of individuals? Is the space set up to comfortably and safely foster and facilitate encounters and engagement among a diversity of individuals? Are the materials designed to provide meaningful reasons to foster and facilitate interactions and discussions among a diversity of individuals?

These three requirements around inclusion echo what is known about learning in informal settings. According to the National Research Council report on informal science learning (2009, pg. 1), learning in informal settings is "…learner motivated, guided by learner interests, voluntary, personal, ongoing, contextually relevant, collaborative, nonlinear, open-ended…". If learning is to be guided by learner interests, then learners must be able to *physically* navigate through and perceive the space so that they are aware of the available learning opportunities from which they can choose. Learning that is "contextually relevant…non-linear, [and] open-ended" requires that learners be able to *cognitively* engage with the learning materials and that the context framing these learning materials reflect a variety of lived experiences. Finally, learning that is "collaborative" requires *social* interactions among a group of learners.

The physical, cognitive ,and social inclusion of all learners, including people with disabilities, needs to be considered by all ISE professionals, especially those who design, implement, and evaluate informal science learning experiences. This report provides descriptions of exemplary inclusive experiences, with the hope that physical, cognitive, and social inclusion will become the norm and not the exception—and ISE will become open, accessible, and inclusive for all.

Status of the field

CAISE AIG investigations suggest that the lack of systemic and accepted professional standards for approaching the inclusion of all individuals—especially those with disabilities—presents the greatest challenge for making inclusion a routine and commonplace practice in the field of ISE. While CAISE AIG investigations located a number of projects, initiatives, and organizations that have sought greater inclusion of people with disabilities in ISE, these efforts are still the exception and not the rule.

This investigation recommends a number of key areas for leveraging change in informal science learning to move forward towards more inclusive practices. These areas are:

- Changes to the standard design of informal learning experiences
- Changes in knowledge of and attitudes toward inclusion among ISE professionals
- Changes in the way the issue of inclusion is framed, with a greater emphasis on the physical, cognitive, and social dimensions of inclusion
- Generation of new understandings of inclusive practices through the study of inclusion and informal science learning
- Development of new designs through cross-pollination within and across different segments of the ISE field.

Combined, these recommendations lay the groundwork for a systemic change in the practices and culture of ISE professionals.

Part 1: Introduction

"If a particular kind of learning is not made socially available to us, there will be no learning to do." (McDermott 1996, p. 277)

As science and technology become increasingly complex and more integrated into the contemporary social fabric, it is urgent that all individuals be provided with the opportunity to learn about, discuss, and engage in the practice of science, technology, engineering and mathematics (STEM). Knowledge and understanding of scientific and technological concepts, processes, discourses, and ways of knowing are critical for individuals to make informed decisions, have a range of employment options, and participate in civic activities. Exclusion from science learning, therefore, can lead to barriers that prevent full participation in society. Currently, many people with disabilities are not afforded full inclusion in informal science learning, hindering their opportunity to learn about science in a way that is equivalent to the opportunities afforded to their non-disabled peers and preventing them from fully participating in an increasingly scientific and technological society. This report sets forth a framework for changing this inequity.

People with disabilities are frequently excluded from full participation in many aspects of American society in ways that are invisible to most Americans. For example, in a recent ruling against the federal government (which is currently under appeal), American paper currency was found to be in violation of the law because it is not differentiated by shape or texture, rendering it inaccessible for persons who are blind (Al-Mohamed, 2006). Exclusion from full participation can be seen to play out in that people with disabilities are less likely to be employed and more likely to live in poverty than their non-disabled counterparts (Waldrop & Stern, 2003). A 2004 Harris Poll found that only 35 percent of working-age individuals with disabilities were employed with either full- or part-time positions as compared to 78 percent of individuals without disabilities (National Organization on Disability, 2004).

People with disabilities also experience exclusion in the realm of formal education. Students with disabilities have recently been granted unprecedented legal protection in the classroom under legislation such as the Individuals with Disabilities Education Act (IDEA, 1997 and 2004; Vaughn, Bos, & Schumm, 2007). Although students are granted such protections, the learning environments are not always reflective of their ways of being and understanding the world (Lee, 1999). The effects are evident in statistics demonstrating that students with disabilities are less likely to graduate from high school or college than their non-disabled peers, and continue to be underrepresented in undergraduate and graduate science degree programs (National Science Foundation, 2004).

The institutions and individuals who create informal science learning experiences have legal, financial, and ethical responsibilities to ensure that informal science learning experiences do not exclude people with disabilities. Legally, institutions that receive federal funding are required to create accessible programs, exhibits, buildings, and technologies under Sections 504 and 508 of the Rehabilitation Act, and public institutions are also required to be accessible under the Americans with Disabilities Act and the Architectural Barriers Act (ADA–ABA). Financially, informal science institutions cannot afford to exclude such a large portion of their potential audiences, as roughly one in five individuals has a disability (Waldrop & Stern, 2003). This number is expected to grow as the population ages and medicine advances. Ethically, as the realm of informal science education (ISE) gathers increasing evidence of its impact on science learning (National Research Council, 2009), it must consider what it would mean if a certain group of individuals were denied access to such valuable experiences based on "atypical" requirements for learning. If it is true that participation in informal science learning activities has many advantages, then it must also be true that exclusion from such experiences would lead to certain disadvantages for those to whom access is denied.

Informal science learning experiences have the opportunity to provide powerful possibilities for people with disabilities to experience and learn about science. When designed to be inclusive, informal science learning experiences can lead people with disabilities to feel competent and empowered as science learners, generate excitement and enthusiasm for science, and be equitable learning experiences that promote learning for all. When such considerations are not taken into account, the result can be experiences where people with disabilities feel disempowered, frustrated, uncomfortable, and alienated from science—that it is "not for them." The potential positive and negative impacts of informal science learning experiences can be found in the following reflections by people with disabilities, gathered through a study that explored the use of science museum exhibits (Reich, 2005):

> *"…Just for the fact that by just feeling the things and listening to the questions and answers, I could solve the problems all by myself. That's a really great feeling."*—Olivia, a blind adult, describing her positive experience at a science museum exhibit
>
> *"But I knew some kind of language or spoken text was happening somewhere around me…and the longer I stayed here the more uncomfortable I got…"*—Leon, a Deaf[1] adult, describing his negative experience at a science museum exhibit

The exclusion of people with disabilities is antithetical to the very nature of informal science education. One of the key characteristics of ISE is that it is intended to serve "learners of *all* ages and backgrounds" (National Research Council, 2009, p. 1). ISE professionals pride themselves on their ability to create environments that promote self-efficacy and feelings that people can learn about science on their own (such as the feelings noted by Olivia above), and seek to eliminate experiences that lead to negative feelings (such as the discomfort experienced by Leon). If the field is to realize this vision of positive ISE experiences for all, it must consider whether its practices truly are inclusive of learners with and without disabilities.

About the report

This report summarizes the investigations and inquiries of the Center for the Advancement of Informal Science Education Access Inquiry Group (CAISE AIG). This group was commissioned to survey the informal science education (ISE) field in order to answer the following questions: 1) In what ways has the ISE field worked to include people with disabilities in informal science learning? and 2) What does prior work tell us about actions that should be taken in the future? This investigation was performed to inform the design, selection, and implementation of future ISE projects.

This report is intended for individuals who work at funding agencies responsible for funding informal science learning programs, future proposal writers, peer reviewers, evaluators, and professionals who design and implement ISE programs, exhibits, and technologies. It also addresses the multiple venues through which informal science experiences are provided, including media and technology, youth and community programs, and science museums, broadly defined.

The report contains four chapters. This introductory chapter is intended to establish a conceptual framework for thinking about the inclusion of people with disabilities in ISE. It includes definitions of key concepts

1 Deaf is capitalized in references to individuals who consider themselves to be culturally Deaf. The lower case, deaf, is used to describe the physical loss of hearing.

such as disability and inclusion, as well as elucidations of ways the design of informal science learning experiences and the practice of ISE professionals can be reconceptualized to promote broader inclusion. Each remaining chapter addresses a specific area of ISE (museums, media and technology, and youth and community programs). These chapters include examples of inclusive informal science learning experiences as well as overarching lessons about practices and designs that lead to the inclusion of people with disabilities in informal science learning.

Defining disability

In recent years, disability studies scholars have put forth a model for understanding and defining disability called the "social model of disability." The social model defines disability as society's response to "human difference," which results in the design of environments for persons whose characteristics fall into the narrow range defined as "normal" and the exclusion of individuals who fall outside that range (Gill, 1999). This model situates the notion of disability within societal and cultural norms and values (Moussouri, 2007), and therefore places the responsibility for change among those who design and develop public spaces, policies, and programs (Barnes, 2003). The social model of disability, therefore, addresses how we define the problem of inclusion. For example, rather than saying that the "problem" lies in the fact that people are in wheelchairs, the social model of disability suggests that the problem is the societal norm that assumes all individuals walk on two legs, which leads to the design of spaces with stairs and no ramps.

The social model of disability is a radical departure from the traditional, medical model which defines disability as a medical defect that can be treated, fixed, or corrected. In contrast to the social model of disability, the medical model of disability places the problem within the individual and defines problems of exclusion as a function of human characteristics that are perceived by others as "not normal." Disability studies scholars argue that the medical model of disability leads to a sense of "ableism," the denial of rights that coincides with the notion that persons with disabilities are somehow "other" (Baglieri & Knopf, 2004; Gill, 1999; Smith, 2001).

The primary societal response to individuals with disabilities under ableist assumptions tends to resonate between two poles. The first pole is one where people with disabilities are represented as dependent and child-like, the needy "Tiny Tims" of charity posters. The second pole presents people with disabilities as exceptions to the rule when they succeed, such as the "supercrip" who "is able to succeed against all odds." Each pole invites a sense of pity towards those who have not succeeded, and includes an ingrained prejudice against designs or practices that may be better—more efficient and more effective—for those with disabilities (Hehir, 2002).

The social model of disability provides a way of understanding the inclusion of people with disabilities in learning outside of the trap of such ableist assumptions (Baglieri & Knopf, 2004). Trent, Artiles, and Englert (1998) propose that the field of special education needs to move away from a deficit framework, where the barriers to learning are considered to reside within the learner, and towards a social constructivist model, where the disability is presumed to result from the interactions of the individual within a specific context that was not designed with his or her physical, cognitive, or sensory characteristics in mind. The social model of disability resonates with those who advocate for culturally-based understanding of disability education, where disability is defined as a cultural experience and exclusion from learning is defined in terms of a lack of acceptance of the ways of knowing that are shared among people with disabilities (Dudley-Marling, 2004; McDermott, 1996; McDermott & Varenne, 1995).

The social model further asserts that the design and implementation of informal learning experiences are influenced by the historical, cultural, and societal norms and values of those who create them. Creating informal science learning experiences that are inclusive of people with disabilities, therefore, requires more than just a fit between individuals with certain characteristics and certain environments; it requires a shift in the definition of who the field considers to be a part of the normal public that engages in informal science learning and subsequently, a redefinition of what a standard informal learning environment is like and how it is designed. It is this very redefinition that is the focus of this report.

Inclusion defined

According to the social model of disability, inclusion is more than simply gaining access into a physical structure—is also about gaining equal access to the policies, practices, and systems that civil society affords (Barnes, 2003). Inclusion in ISE, therefore, goes further than ensuring that people with disabilities can enter or use the buildings, programs, and technologies that deliver such experiences. It also requires that people with disabilities are able to learn from such experiences and participate as a part of, and not separate from, the larger social group and community. Similar to definitions of inclusion from the field of formal education (Blamires, 1999), inclusion in ISE experiences has physical, cognitive, and social dimensions. Inclusion in ISE therefore requires that learners be able to:

> **Physically interact with/perceive the space**—Key design questions include: Is the space set up so that a diversity of individuals can move around the space comfortably and safely? Is the information in the space conveyed in a variety of formats so that a diversity of individuals can perceive it? Can a diversity of individuals manipulate or cause things to happen within the space?
>
> **Cognitively engage with the materials**—Key design questions include: Is the information conveyed using a range of media to allow a diversity of individuals to engage with the materials? Do the materials take into account a diversity of individuals with a range of learning and cognitive skills? Do the materials take into account a diversity of individuals with ranges of experiences and sets of background knowledge?
>
> **Socially interact with one another**—Key design questions include: Is the environment generally safe and welcoming for a diversity of individuals? Is the space set up to comfortably and safely foster and facilitate encounters and engagement among a diversity of individuals? Are the materials designed to provide meaningful reasons to foster and facilitate interactions and discussions among a diversity of individuals?

CAISE AIG investigations revealed that the ISE field is more likely to consider aspects of physical and cognitive inclusion than social inclusion. It is the last element of social inclusion, however, that is essential to full inclusion in ISE. Social inclusion in informal science learning promotes a message that learning about and participating in science is something that is for *all* learners, including learners with disabilities.

These three elements of inclusion echo what is known about learning in informal settings. According to the National Research Council (NRC) consensus report on informal science learning (2009, p. 1), learning in informal settings is "…learner motivated, guided by learner interests, voluntary, personal, ongoing, contextually relevant, collaborative, nonlinear, open-ended…". If learning is to be guided by learner interests, then learners must be able to *physically* navigate through and perceive the space so that they are aware of the available learning opportunities from which they can choose. Learning that is "contextually relevant…non-linear, [and] open-ended" requires that learners be able to *cognitively* engage with the learning materials and that the context framing these learning materials reflect a variety of lived experiences. Finally, for learning to be “collaborative” requires *social* interactions among a group of learners.

The physical, cognitive, and social inclusion of all learners, including people with disabilities, needs to be considered by all ISE professionals, especially those who design, implement, and evaluate informal science learning experiences. This report provides descriptions of exemplary experiences that reflect these levels of inclusion, with the hope that physical, cognitive, and social inclusion will become the norm and not the exception—and ISE will truly become open, accessible, and inclusive for all.

Inclusion through the reconceptualization of design

The physical, cognitive, and social inclusion of people with disabilities involves a reconceptualization of the approaches ISE professionals utilize to design and implement informal science learning experiences. Two design approaches that ISE professionals could utilize include *universal design* and *assistive technologies*. It should be noted that while each of these approaches represents a different philosophy of design, it does not mean that they are mutually exclusive. In fact, there are benefits when these approaches are used in tandem, so that assistive technologies promote further access beyond what is already achieved through universal design.

Universal design, 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,” is one approach ISE professionals can use to create environments that are physically, cognitively, and socially inclusive (Center for Universal Design, 2002). Universal design promotes inclusion through a designed environment that does not stigmatize based on physical, cognitive, and sensory characteristics (Story, Mueller, & Mace, 1998). The process that leads to the development of universal design reflects a philosophy that considers all individuals located on a broad spectrum that ranges from able to disabled. Where a person is positioned on that spectrum depends upon his or her individual needs, the context of the interaction *and* the designed environment. The process of universal design is generally guided by a series of design principles, rather than exact measurements, and encourages thinking about inclusive designs from the beginning rather than as a retrofit at the end of the design process. Through the years, a number of principles of universal design have been created, including those used for architecture and product development (Story et al., 1998), instruction (Bowe, 2000) and learning (Rose & Meyer, 2002).

Examples of universal design are present in a variety of informal science learning experiences, including science museum exhibitions, media and technologies, and youth and community programs. The *Wild Music* exhibition developed by the Science Museum of Minnesota (ESI-0407373), for example, was designed to be inclusive of visitors of a broad range of abilities, and reflects the principles of universal design for learning (Rose & Meyer, 2002). This exhibition features multiple methods of communicating information (text, audio, and tactile images), multisensory interactives that provide visitors with multiple pathways for interacting with the content of sound, and multiple topical approaches to sound that would appeal to a variety of interests (anthropology, ecology, and anatomy, to name a few). Further examples of how ISE professionals and institutions have embraced universal design as a solution for inclusion are addressed in the remaining chapters of the report.

Universal design is not the only method used to create physically, cognitively, and socially inclusive environments. Another approach is to provide assistive technologies that serve as aids for learners with specific disabilities. 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, as is a screen-reader that provides people who are blind with the ability to navigate through the Internet. When used under ableist assumptions, the use of assistive technologies can lead to the stigmatization of persons with disabilities and separate designs for "special" user groups (Story et al., 1998). CAISE AIG investigations found that the use of assistive technologies can be utilized to promote physical, cognitive, and social inclusion if such technologies are implemented in settings that include other universal design features and are intended for use in spaces also utilized by people without disabilities. For example, the summative evaluation of the *Star Wars: Where Science Meets Imagination* exhibition (ESI-0307875) found that the use of a handheld device that provided virtual American Sign Language interpretation prompted discussions between a deaf husband and his wife as he shared with her information he learned through the device that was not available in the text label (Tisdal, 2007).

In addition to universal design and assistive technology, there are a number of other strategies utilized to educate people with disabilities, including response to intervention (RTI) and specialized programs. These strategies, however, are largely based on the medical model of disability. They do not necessarily promote physical, cognitive, and social inclusion of people with disabilities and therefore are not recommended as models for informal science learning.

Response to intervention (RTI) is currently the dominant model within the field of formal education. A strategy utilized in schools to diagnose children with learning disabilities, this approach looks to define someone as having a learning disability based on his or her inability to learn across a variety of curriculum and teaching approaches. RTI requires that teachers monitor a student's progress over time, and looks to see whether there is an improvement in the student's ability to write, read, and calculate, based on changes in instruction (Batsche, Kavale, & Kovaleski, 2006; Fuchs & Fuchs, 2006).

Despite its dominant status in formal education, this strategy is not recommended as a model for inclusion in informal science learning for a number of reasons. First, an RTI approach would be difficult to implement in most settings that promote informal science learning. It requires that there be someone who is trained in accurately assessing student improvements and that this individual have the ability to monitor changes (or the lack thereof) over time. With the exclusion of community programming, most informal learning experiences do not afford the opportunity for this style of monitoring. Second, RTI places the barrier to inclusion *within* the student, and not the larger context. While there may be a need for formal education structures to have a way to accurately identify students with learning disabilities, this need is not as present in informal education. Thirdly, RTI is an approach to indentifying students with specific learning disabilities and their challenges in reading and decoding text (Scanlon, 2003). As reading is only one of multiple literacies in informal science learning, the approach is neither broad nor methodologically robust enough. Finally, the anxiety created through on-going testing, monitoring, and diagnosing could detract from the excitement and engagement that is promoted in informal learning environments, which are traditionally absent of such testing pressures. It is therefore recommended that informal science learning environments focus on the assets of the learners, and not their deficits.

Another strategy frequently implemented is the use of specialized programs that are intended only for people with disabilities. These programs can serve important roles, including providing people with disabilities with a sense of community and serving as stepping-stone programs that help people with disabilities develop skills that make it more likely that they will be successful when they participate in inclusive programming. Despite these benefits, these programs do not serve as models for physical, cognitive, and social inclusion. The exclusionary nature of these programs can detract from informal science learning as conversations among peers and collaborators play a critical role in facilitating science learning in and out of the classroom (Leinhardt, Crowley, & Knutson, 2002; Palincsar, Collins, Marano, & Magnusson, 2000; Palincsar, Magnusson, Collins, & Cutter, 2001). In addition, there is some evidence that inclusive ISE experiences may be preferred by people with disabilities. Research from the field of leisure studies and tourism has found that social motivations—including being together with family and friends—is one of the primary reasons people with disabilities participate in tourism experiences, such as museums (Poria, Reichel, & Brandt, 2009). Social inclusion is also increasingly becoming the expected norm among many in the disability communities. The disability rights movement has framed inclusion as a civil rights issue (Fleischer & Zames, 2001; Jaeger & Bowman, 2005), and laws such as the Americans with Disabilities Act and the Rehabilitation Act confirm this right. Changes in educational policy put forth by IDEA 2004, and the primacy this law places on inclusion, have also changed the expectation of inclusion for children with disabilities and their parents.

Moving toward more inclusive informal science learning experiences

The social model of disability requires that institutions and professionals assess their own practices and policies and examine the barriers they pose to the full inclusion of people with disabilities. Investigations conducted by the CAISE AIG point to current field-wide practices that pose a number of barriers to inclusion. There are, however, exceptions. CAISE AIG investigations also revealed that some ISE professionals and institutions are taking action to advance the inclusion of people with disabilities, and these actions are leading to improvements in informal science learning for all. These practices serve to guide a new vision of what inclusive informal science learning can be.

The CAISE AIG identified the following needs—and opportunities:

- The need to change the standard design of informal learning experiences
- The need to increase knowledge of and attitudes toward inclusion among ISE professionals
- The need to change the way the issue of inclusion is framed
- The need for cross-pollination

The need to change the standard design of informal learning experiences

The physical design of learning spaces and materials, whether virtual or real, can lead to significant barriers that prevent people with disabilities from being included in informal science learning. Physical barriers can be posed by the physical layout of a building or website, which can make it difficult for individuals with disabilities to obtain access to the learning they seek. For example, the navigational structures of many websites are not designed for ease of use by individuals who use screen readers, and museums rarely provide non-visual navigational aids. As such, an over-reliance on any one communication medium, and an assumption that one communication medium fits the needs of all learners, can cause significant physical barriers for those for whom that medium is imperceptible. For example, written text can be difficult to read for learners who are blind or have low vision, learners who are dyslexic, and learners who are deaf,[2] yet most museums rely only on text labels as the main medium for communicating instructions and content messages.

Current instructional designs also serve as barriers. Many inquiry-based informal science learning activities do not provide design-based mechanisms for scaffolding or supporting learners as they engage in science inquiry activities in informal settings. Scaffolding is a process by which learners are provided with initial help in areas

2 Persons who are deaf generally have lower reading levels than persons who are hearing as their acquisition of English is affected by their inability to hear oral discourse (Padden & Ramsey, 1998; Schirmer & McGough, 2005).

where they are struggling as learners (this help can be provided by either another person such as a parent or educator or by the design of the learning experience); gradually this help is eliminated as the learner develops increased expertise. This process has been shown to be essential for engaging students with learning and developmental disabilities in science inquiry activities in the classroom (Mastropieri, Scruggs, & Magnusen, 1999; Palincsar et al., 2000; Palincsar et al., 2001; Scruggs, Mastropieri, & Boon, 1998).

Additionally, connections between hands-on science activities and real-world contexts are not always present in informal science learning. If such connections are made, little thought is often given to the possible differences in real-world connections for visitors with different lived experiences. For example, in exhibits and programs about physics, "riding a bicycle" is often used as an analogy, but not every learner has had the experience of riding a bicycle. Relevant connections that relate to disability culture are critical for considering inclusion in informal science learning for learners with disabilities (Gersten & Baker, 1998; Lee, 1999; National Research Council, 2009).

Solutions to the barriers posed by the physical and instructional design can be found in practices that utilize multisensory and multimodal ways of communicating and interacting to promote physical inclusion and a greater emphasis on the use of scaffolds and supports to promote cognitive inclusion.

The need to increase knowledge of and attitudes toward inclusion among ISE professionals

Existing knowledge (and lack thereof) and attitudes of ISE professionals can pose significant barriers to inclusion. While it is difficult to find research that examines the knowledge and attitudes toward inclusion of ISE professionals, research from the field of formal education suggests that current knowledge may be limited and attitudes toward disability may not always be positive. A survey of 189 science teachers who taught elementary, middle, and high school, and undergraduates studying science education revealed that the majority of the respondents did not feel adequately prepared to teach the students with disabilities who were in their classrooms. Responding teachers also reported negative attitudes and misconceptions about students with disabilities. For example, over half of the teachers surveyed "agreed that disability categories are too often used as an excuse for failure" and over 40 percent "felt that students with disabilities should not be given unrealistic goal expectations because they will inevitably be frustrated in their search for employment" (Norman, Caseau, & Stefanich, 1998, p. 137). While these statistics do not represent the existing attitudes of ISE professionals, the high rate of negative attitudes within formal education professionals suggests that some ISE professionals might hold similar negative conceptions as well.

Professional development programs for ISE professionals offer one solution for addressing this barrier. Such programs should address both existing knowledge gaps about ways to design and implement inclusive informal science learning experiences as well as focus on decreasing ableist assumptions concerning the ability of people with disabilities to learn about science. This could be achieved through programming that supports learning about disability and inclusive practices in a structured way that highlights the assets of people with disabilities and does not promote feelings of pity.

The evaluation of the Association of Science-Technology Centers (ASTC) *Accessible Museum Practices* initiative (ESI- 9814917 and HRD-9906095) provides insights on elements that might be important to include in such professional development programs. These include presenting ISE professionals with the opportunity to work with people with disabilities and providing them with published guidelines and materials (Hein, 2002, 2003). Similar findings appear in studies from the field of formal science education. Professional development programs that include opportunities for teachers to learn about ways of working with students who have disabilities, and then engage in collaborative, hands-on activities with these students have been shown to be effective at generating positive teacher attitudes towards such learners, whether working with preservice teachers (Bishop & Jones, 2003), or veteran science teachers (Jeon & Haider-Markel, 2001).

Another avenue for addressing the knowledge and attitudes of ISE professionals is to engage people with disabilities in the work of ISE. This direct involvement addresses one of the essential tenets of the disability rights movement, "nothing about us without us" (Charlton, 1998). This slogan highlights the importance of people with disabilities being able to speak for themselves and being involved in decisions concerning their rights and needs. Involvement of people with disabilities in the work of ISE may also lead to longer term changes as there is the possibility that the individuals and organizations who work with people with disabilities will learn more deeply about inclusion through such collaborations. It is also possible that working with people with disabilities leads to a positive change in attitude toward disability (Yuker & Block, 1986). As negative impacts on attitude toward disability have been found when people without disabilities interact with people with disabilities in settings where only the difficulties of living with a disability is emphasized (Weisel, 1988), the involvement of people with disability in the design, development, and implementation of informal science learning experiences should highlight and utilize this individual's strengths and knowledge, and should not just be a symbolic gesture.

The need to change the way the issue of inclusion is framed

A less concrete barrier, but no less significant, is the current way society tends to talk about or "frame" the problem statement of inclusion. The occurrence and use of certain frames within public discourse is significant as it can be an indicator of the progress of social movements (Gamson, 1998). Those in the disability rights movement view inclusion as a sociopolitical movement that requires a change in the definition of normal and an emphasis on access for all individuals, including those whose physical, cognitive, and sensory characteristics fall outside of the societally determined normal range. Other dominant non-inclusion frames, however, still persist within discussions of disability, and these frames can be linked to a lack of action. Some frame disability as a medical issue that solely requires the treatment of certain individuals. Others frame it as an economic issue and conclude that society does not have the financial ability to pay for the needs of a "select few" or view inclusive practices as a deterrent to innovation or economic progress. To move forward, therefore, ISE professionals need to do more than change their designs and knowledge; they also need to establish a new way of viewing and framing their work.

The reframing of efforts toward inclusion may lead to the widespread change in practice toward inclusion that the field requires, particularly if the reframing focuses on the social model of disability frame of inclusion for all. Within the realm of formal education, it has been found that when professionals within an institution take the stance that inclusion leads to improvements for all, there is more likely to be a sustained change in action (McLeskey & Waldron, 2006). The message of universal design—and the idea that designs for people with disabilities can improve practice for people without disabilities—also resonated with the professionals who participated in ASTC's *Accessible Museum Practices* initiative (Hein, 2003). Inclusion could also be reframed as an ideal to work towards and a constraint to work within rather than a barrier to creativity; all designs face constraints, and from those constraints can come true innovations (Kelley & Littman, 2001).

The need to study inclusion of people with disabilities and informal science learning

There is currently a dearth of research that addresses the inclusion of people with disabilities in informal science learning. As the NRC report concludes, "The literature on science learning in informal environments for people with disabilities is extremely thin" (2009, p. 227). There is also a lack of evaluation studies that have examined the impacts of inclusive informal science learning experiences. CAISE AIG investigations demonstrated that there have been few attempts to measure the impact of informal science learning experiences on people with disabilities, even when inclusion was a major focus of the effort; even when and a summative evaluation was conducted, it involved people who did not have disabilities. This current lack of empirically based understandings of inclusion places the field at a distinct disadvantage and contributes to the existing professional knowledge gap. More research and evaluation studies that address inclusion are needed if the field is to move forward in this area.

The need for cross-pollination

In the pursuit of inclusion of people with disabilities in informal science learning, cross-pollination could play an important and integral role. Cross-pollination "…is a kind of alchemy of innovation" (Kelley & Littman, 2001, p. 49), which allows for practitioners, researchers, evaluators, and participants with a wide range of experiences to learn from each others' work and develop new solutions for inclusion. While there are a number of initiatives in the field of informal science learning that seek to foster inclusion, and a larger number of individuals within the field who support these goals, there is little communication among the various areas of informal science learning (such as between those who create new media and those who create out-of-school time programs), even though such communication, collaboration, and cross-pollination would be very beneficial to the goal of inclusion. Cross-pollination can occur across the public and private sectors, where there are a number of technologies, initiatives, knowledge, and energies that could be leveraged, as well as between ISE and formal education, where the field of inclusion is more established and can serve as a resource and model for informal science institutions. As such, it is necessary to include the goals of inclusion in ISE in infrastructure-type initiatives, such as the ASTC ExhibitFiles community website and NSF's Cyberinfrastructure program, and to foster spaces—online and offline—that allow for the dialogue and sharing required for this form of cross-pollination.

Status of the field

CAISE AIG investigations suggest that the lack of systemic and accepted professional standards for approaching the inclusion of all individuals—especially those with disabilities—presents the greatest challenge for making inclusion a routine and commonplace practice in the field of ISE. While CAISE AIG investigations located a number of projects, initiatives, and organizations that have sought greater inclusion of people with disabilities in ISE, these efforts are still the exception and not the rule.

This investigation recommends a number of key areas for leveraging change in informal science learning to move forward towards more inclusive practices. These areas are:

- Changes to the standard design of informal learning experiences
- Changes in knowledge of and attitudes toward inclusion among ISE professionals
- Changes in the way the issue of inclusion is framed, with a greater emphasis on the physical, cognitive, and social dimensions of inclusion
- Generation of new understandings of inclusive practices through the study of inclusion and informal

science learning

- Development of new designs through cross-pollination within and across different segments of the ISE field.

Combined, these recommendations call for nothing less than a systemic change in the practices and culture of ISE professionals. While CAISE AIG investigations located a number of projects, initiatives, and organizations that have sought greater inclusion of people with disabilities in ISE, these efforts are still the exception and not the rule.

Changing educational practice is no small endeavor. Much has been written within the field of organizational learning (for example, Argyris & Schön, 1995; Beer & Nohria, 2000; Kotter & Cohen, 2002) and formal education (for example, Elmore, 1995; Fullan, 2007; Hargreaves & Fink, 2006; Hargreaves & Fullan, 2009; Hargreaves & Shirley, 2009). Currently, there is no research ISE professionals can turn to if they are looking to effect a change toward inclusion within their organizations. To date, no study has looked at this topic from an institutional or professional level. Compounding the lack of research that looks at change in practice toward inclusion is a dearth of research in the ISE field that looks at organizational or educational change (Griffin et al., 2007). Only a few studies to date have addressed this topic (Abraham, Griffin, & Crawford, 1999; Ogawa, Crain, Loomis, & Ball, 2008; Ogawa, Loomis, & Crain, 2008; Roberts, 1997).

Given the lack of research in the ISE field that looks at conditions that support changes in educational practices, one must look to other disciplines such as formal education and organizational learning for possible solutions. A few studies from these fields have examined the conditions that lead to sustained change in practices that in turn lead to greater inclusion of people with disabilities. Such scholarship provides a number of plausible explanations for why certain ISE institutions are successful at sustaining change towards inclusion when others have failed. A study examining not-for-profit organizations and hiring practices found that organizations were more likely to take action when an informal leader championed the effort (Hamner, Hall, Timmons, Boeltzig, & Fesko, 2008). This leadership was not necessarily due to the individual's formal position, but rather derived from his or her being well-networked throughout all levels of the organization and with like-minded individuals from other organizations. Alternatively, a study on inclusive school practices found that successful change occurs when: 1) there is support for the change in all levels of the organization, 2) schools are empowered to manage their own change, 3) efforts for inclusion focus on improving practice for all students and not just students with disabilities, 4) the change is specifically tailored to meet the needs of the individual school and students, 5) efforts are based on prior research and proven practices, and 6) variation and difference in student abilities is considered normal (McLeskey & Waldron, 2006).

It should be noted that federal agencies may be able to play a role in pushing for a change in practice toward inclusion. In recent years, evaluation has become the norm in ISE, with evaluation departments in almost every large science museum in the United States—a change stimulated in part by policies of the NSF and the Institute of Museum and Library Services (IMLS) that made an evaluation plan a precondition of funding. A similar effort could be taken toward inclusion of people with disabilities in informal science learning. Given that the inclusion of people with disabilities is a requirement of Section 504 of the Rehabilitation Act, federal agencies could require that institutions seeking federal funding submit an accessibility plan with their proposal that details actions the proposer will take to include people with disabilities. Such a requirement could lead to a tipping point that begins to establish inclusion as a field-wide norm. In addition, Section 504 Compliance Reviews (such as those currently being carried out by NASA) provide another avenue for ensuring that those institutions receiving federal funding are in compliance with the law and are actively working to include people with disabilities in informal science learning.

Creating and sustaining change toward inclusion in informal science learning will not be easily achieved; it will involve the ongoing commitment a broad range ofl ISE professionals, including (but certainly not limited to) individuals who work at agencies responsible for funding informal science learning programs, future proposal writers, peer reviewers, evaluators, executive directors, and professionals who design and implement ISE programs, exhibits, and technologies. Despite the difficulty, it is critical that the field move forward to push for the greater inclusion of people with disabilities in informal science learning as it has a legal and ethical responsibility to do so.

CAISE AIG investigations demonstrate that greater inclusion of people with disabilities in ISE is achievable. The exemplary practices described in the remaining chapters of the report provide the evidence that it is possible to establish ISE practices, programs, and designed environments that are open, accessible, and inclusive for all.

—Christine Reich, Jeremy Price, Ellen Rubin, Mary Ann Steiner

Principles of Universal Design

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 "Principles of Universal Design" developed by the Center for Universal Design (Story et al., 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

An alternative framework developed specifically for formal learning at the university level is the "Principles for the Universal Design of Instruction," which are based on the original principles developed by the Center for Universal Design (Bowe, 2000):

- Equitable use
- Flexibility in use
- Simple and intuitive instruction
- Perceptible information
- Tolerance for error
- 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 principles of universal design, which were created to address the development of curriculum and multimedia 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
- To provide multiple ways to engage students' interest and motivation.

Part 2: Inclusion in Museums

Christine Reich

Science museums[1] play an integral role in civil society. Among the few physical places members of the public can visit and learn about science (National Research Council, 2009, p. 127), they are also social institutions (Janes & Conaty, 2005) that reflect the scientific ideas, knowledge, artifacts, and processes society feels are worthy of disseminating to current and future generations. As such, they serve not only as important institutions for learning, but also as symbols of the enterprise of science, technology, engineering, and mathematics (STEM) for the communities they serve. Given this, it is essential that people with disabilities be included in science museums. Inclusion not only provides access to the rich, informal science learning experiences that museums afford; it also has a symbolic purpose and sends a message that people with disabilities can be, and are, a part of civil society and the scientific enterprise.

What it means for a science museum to be inclusive of people with disabilities is largely based on what engages visitors in science and science learning during their visits. As stated in the NRC report *Learning Science in Informal Environments* (2009, p. 127), museums are among the few spaces that are "intentionally designed for learning about science and the physical and natural world." Given this, the *physical* design of the space plays a critical role in engaging visitors in learning about science. Science museums also offer many self-directed activities that make science learning possible in these spaces, and therefore the design of the *cognitive* goals and activities also plays an essential role. Finally, museums are *social* environments, and the learning that takes place within museums is often facilitated through person-to-person interactions, including conversations (Leinhardt, Crowley, & Knutson, 2002). Inclusion in museums therefore requires the following:

> Designed spaces in which the learning takes place (such as exhibits and classrooms) and necessary amenities (including bathrooms and restaurants) that enable visitors with a diverse range of abilities to *physically* interact with and perceive the environment.
>
> Learning activities (including living collections, artifacts, hands-on experiments, models, theater presentations, and media) that provide the opportunity for visitors with a diverse range of abilities to *cognitively* engage with the learning materials.
>
> An overall environment that supports visitors and museum educators with a diverse range of abilities in interacting with and learning from one another, whether those social interactions take place among family members, within school groups, or between visitors and museum educators.

Also important is that people with disabilities *perceive* that museums are inclusive of their needs. This perception is essential if museums wish to portray the message that people with disabilities are a part of the scientific and civic life of these very public institutions.

This chapter presents examples of museum efforts that reflect the physical, cognitive, and social inclusion of people with disabilities. This information was gathered by the CAISE AIG through a process that sought to identify recent work conducted by science museums that was aimed at the inclusion of people with disabilities

1 In this report, the term "science museum" refers to any museum that offers visitors the opportunity to learn about the natural and physical world—including zoos, aquariums, planetariums, natural history museums, nature centers, arboreta, botanical gardens, and science and technology centers. Also included are children's museum exhibitions that are focused on engaging children in learning about science. All of these institutions fall within the American Association of Museum's definition of a "museum" (American Association of Museums, 2000).

in informal science learning. Actions taken to identify this work included the following:

- surveying members of the Informal Science Education email discussion list ISEN-ASTC-L
- searching for articles through education and arts-related databases
- hosting a session during the July 2008 ISE Summit, including asking participants to identify projects they and others had worked on that addressed inclusion of people with disabilities
- attending sessions and speaking informally with participants at annual conferences of ASTC, American Association of Museums, and the Visitor Studies Association
- searching for current and recent inclusion-related projects using the NSF and IMLS grant databases
- conversing with individuals who have extensive experience in the area of inclusion and asking for further contacts
- establishing a museum-specific advisory committee that provided ongoing advice about projects and institutions that were seeking greater inclusion.

By examining the previous work of the science museum field, the CAISE AIG team sought to 1) synthesize what is already known about the inclusion of people with disabilities in science museums, 2) identify effective practices that could be replicated across the field, 3) pinpoint areas where more work is needed, and 4) identify some of the barriers that currently prevent greater inclusion of people with disabilities in science museums. At the end of this chapter, lessons learned through the review of these efforts are synthesized into recommendations for funders and the broader ISE field.

Examples of inclusion in museums

The CAISE AIG identified approximately 40 examples of efforts to create inclusive learning environments in science museums. These clustered as follows:

Project-level efforts—discrete products or projects that are inclusive of people with disabilities.

Organizational efforts—institution-wide efforts, sustained over time, to create overall museum environments that are inclusive of people with disabilities.

Resources—new knowledge and materials that can be used within institutions and by the wider field to create science museum learning environments that are inclusive of people with disabilities.

Project-level efforts

Through its investigations, the CAISE AIG identified 31 museum exhibitions, programs, and technologies that specifically sought to engage people with disabilities in science museum learning.

Museum exhibitions

Many museums are engaging in efforts to create museum exhibitions that are inclusive of people with disabilities. CAISE AIG investigations identified 22 inclusive exhibition projects. These exhibitions emphasized multisensory and multilayered experiences that encouraged visitors to engage with scientific ideas and activities using their sense of sight, touch, hearing, smell, and sometimes even taste. Inclusive exhibitions also featured designs that were physically inclusive, enabling use by visitors with and without disabilities. Exhibition projects took place across a variety of science museum types, and took on a multitude of forms, including sensory gardens, tactile models, and multisensory, multimodal interactive exhibits.

Sensory gardens—A number of botanical gardens, including the Brooklyn Botanic Garden, the Chicago Botanic Garden, and the Huntington Botanical Gardens in San Marino, California, now have sensory gardens—experiences intentionally designed to promote inclusion of people with disabilities. Physical inclusion is often achieved through the use of paved pathways, curb cuts, and raised flower beds that make it easy for visitors of a broad range of abilities to navigate through the designed space. Cognitive inclusion is often promoted through the use of fragrant and tactilely pleasing plants, auditory landscape elements, and sometime Braille labeling. Social inclusion is promoted through the intention that these gardens be used by all visitors, not just those with disabilities.

The *Lerner Garden of the Five Senses at the Coastal Maine Botanical Gardens* in Boothbay, Maine, is a notable example of a sensory garden. This garden, which offers 1.5 acres of accessible plantings, reflects lessons learned from institutions across the nation about ways to design botanical gardens so that they are physically, cognitively, and socially inclusive of people with disabilities. The garden features a tactile map at the entrance that provides a mechanism for visitors to feel and see the layout of the garden and the pathway they wish to explore. This map is important not only because it enhances physical access to the garden, but also because it serves to signify right at the entryway that this experience is inclusive of people who are blind. Raised beds throughout the garden make it easy for visitors to touch and smell the fuzzy and fragrant plants even if they approach these plants from a seated position or are unable to bend down. The garden also features waterfalls where visitors are encouraged to feel and listen to the rush of the falling water, whether from a seated or a standing position.

The Lerner Garden of the Five Senses at the Coastal Maine Botanical Gardens is a garden all visitors can enjoy. *Photo by Wendy Pollock*

Sensory gardens not only offer rich, multisensory ways to interact with and learn about the living botanical world, but they may serve therapeutic purposes as well. A study conducted at the Morikami Museum and Japanese Gardens in Delray Beach, Florida, found that garden visitors who had been diagnosed as depressed experienced reductions in their depression after participating in an intervention that featured walks through the gardens (McCaffrey, 2007). The possibilities for both educational and therapeutic benefits of sensory gardens for people with and without disabilities make these kinds of experiences particularly valuable as inclusive exhibit experiences.

Tactile models—A number of institutions are using tactile models to promote cognitive inclusion of people who are blind or have low vision. Usually these are scale models that represent historic technological artifacts, living collections (like those in zoos and aquariums), and other artifacts of scientific note. Tactile models also promote social inclusion as they can be utilized by all visitors to gain deeper insights into aspects of the artifact that can only be gained via touch (Wing, Giachritsis, & Roberts, 2007). Evaluations of art and science museum exhibitions have found that the presence of tactile models in artifact-based exhibitions increases enjoyment and learning for visitors with and without disabilities (Davidson, Heald, & Hein, 1991; Onol, 2008). Therefore, it is likely that all members of a social group can learn together in exhibitions that include tactile models.

Notable examples are scale models of the Gemini and Mercury rockets currently installed at the New York Hall of Science in Queens, which were created by Touch Graphics, Inc. (SBIR-0421973). These tactile models are digitally enhanced so that as visitors touch different parts of each model, a computer provides audio and visual interpretations describing what that part of the rocket is and why it is significant.

The digitally enhanced, touchable rocket models at the New York Hall of Science provide audio and visual interpretation of the actual Mercury and Gemini rockets that are located nearby. *Photo courtesy New York Hall of Science*

Creating tactile models that provide meaningful and aesthetically pleasing learning experiences for visitors with and without vision is still a challenge for science museums as little is known about what makes for an effective tactile model design (Spence & Gallace, 2008). Research from the field of neuroscience demonstrates that many factors influence our perception of what we touch, including stimuli received through other senses (Spence, 2007). A study conducted in art museums suggests that many of the existing tactile experiences in museums that are designed for people who are blind or have low vision do not provide positive learning experiences for these visitors (Candlin, 2003). An evaluation of tactile models at the Museum of Science, Boston, found that many factors influence whether a tactile model is an effective learning tool for people who are blind or have low vision. These factors include 1) auditory navigation information that helps visitors to determine how to explore the model, 2) the right balance between too few tactile cues (which leave visitors unsure what something represents) and too many cues (which make it difficult for visitors to detect what is important to notice about the model), and 3) high-contrast colors and textures to distinguish different parts of the model from one another (Chin & Lindgren-Streicher, 2007). There is still much that the science museum field needs to learn about ways to create tactile model experiences in museums that are physically, cognitively, and socially inclusive of people with disabilities, and perceived by all visitors as valuable learning experiences.

Multisensory, multimodal interactives—Multisensory, multimodal, interactive experiences are being produced by children's museums and science centers to engage people with and without disabilities in hands-on science learning. Cognitive inclusion is achieved in these exhibitions through the presence of activities that invite visitors to utilize all of their senses (including smell, hearing, touch, sight, and sometimes even taste) as they explore scientific ideas and engage in science inquiry, plus interpretive information delivered through text, audio, images, and video. These multisensory, multimodal elements are important for visitors with disabilities—including visitors who are dyslexic, deaf, hard of hearing, or blind or who have low vision or nonverbal learning disabilities. These exhibitions are also often designed to be physically inclusive of people with disabilities and provide interactives at a height accessible to children and adults (both seated and unseated), clear pathways for easy navigation, a variety of seating options, and labels with easy-to-read, high-contrast fonts (American Association of Museums, 1998; Smithsonian Accessibility Program, 1996). Social inclusion is promoted as well, as some of these exhibitions intentionally utilize design features that

Multisensory, multimodal interactives in *Wild Music* improve access for visitors of a broad range of abilities and disabilities. *Photo by Wendy Hancock*

promote family learning conversations (Borun et al., 1998). A notable example of a multisensory, multimodal interactive exhibition that is physically, cognitively, and socially inclusive is *Wild Music: Sounds & Songs of Life* (ESI-0407373), which was created by the Science Museum of Minnesota in collaboration with ASTC and the University of North Carolina at Greensboro School of Music. (See page 37 for a description of this exhibition.)

The design of contemporary multisensory, multimodal interactive exhibitions in many ways reflects the principles of universal design for learning that apply to the design of classroom curriculum (Rose & Meyer, 2002), which state that inclusive curriculums are those that provide multiple means of representation, action and expression, and engagement. For example, *Wild Music* uses multiple media to communicate ideas about sound—including tactile images, text labels, and audio labels. This exhibition also provides multiple means for visitors to take action and express themselves in the exhibition through the use of interactives that engage multiple senses; some of the interactives are tactile, others are visual, and many are auditory. Finally, the exhibition also provides many ways for visitors to engage with and get excited by and interested in the content from many different perspectives—anthropological, ecological, acoustical, and biological.

Evaluations of multisensory, multimodal interactive exhibitions demonstrate that these experiences can be effective at engaging visitors with and without disabilities in learning about science (Department of Evaluation and Research in Learning, 2007; Karp & Leblang, 2004; Tisdal, 2007) and that exhibition design features that enhance access for people with disabilities will be used by people without disabilities and can improve learning for a much broader audience as well (Davidson et al., 1991). In addition, a research study that took place in a children's museum and explored the experiences of children with learning and behavioral disabilities in multisensory, science-based exhibitions found that the performance differences that were evident in the classroom between students with disabilities and those without did not exist in this type of museum setting; all students were engaged with learning, connected the exhibits to their everyday lives, and interacted with each other in positive ways while in the museum (Rapp, 2005).

Museum programs

CAISE AIG investigations identified eight museum educational programs designed to be inclusive of people with disabilities. These included out-of-school time programs for children, drop-in programs that take place on the museum floors, and assistive materials that are implemented by parents with their children in the museum. Similar to museum exhibitions, inclusive museum programs feature multisensory, multimodal materials that promote cognitive inclusion; spaces that take into consideration a broad range of needs and address physical inclusion; and practices that intentionally promote social inclusion through interactions between people with and without disabilities. Museum programs also feature another important element—museum educators (including managers, paid staff members, and volunteers) who have been trained to be aware of the needs of people with disabilities and who themselves may or may not have disabilities.

Out-of-school time programs—Many museums host science-based out-of-school time programs for children and teens. A few (notably, the Science Museum of Minnesota, St. Paul; the Pacific Science Center, Seattle; and the Lincoln Park Zoo, Chicago) have taken action to ensure that such programs are inclusive of people with disabilities. Specifically, these museums have trained staff members about inclusion, designed the programmatic spaces and activities so that they are comfortable for children with and without disabilities, and made sure that parents feel welcome to both register children with disabilities for these programs and inform the museum of their children's needs. While there is some debate about whether museums should create separate versus inclusive programs for children with disabilities, it is worth noting that inclusive programs may be the expected norm now that schools promote the inclusion of students with disabilities. A recent survey conducted by the Pacific Science Center found that most parents of children who fall along the autism spectrum would prefer that their children participate in inclusive programs that enable interactions between children with and without disabilities (Pacific Science Center, 2009).

Access is enhanced for this NISE Net program through the use of a tactile carbon nanotube model all visitors can touch. *Photo courtesy NISE Net*

Drop-in programs—Drop-in programs in museums take many forms and can include stage presentations, interpretation carts, and science theater presentations. A few museums are considering ways to design such experiences so that they are inclusive of people with disabilities and encourage family and school groups that include people with and without disabilities to learn together. A design charrette conducted as a part of the Nanoscale Informal Science Education Network (NISE Net, ESI-0532536) concluded that inclusive drop-in programs were those that adhere to the following guidelines:

- Repeat and reinforce the main ideas and concepts by communicating the message through multiple media and representing these ideas in different ways.
- Make multiple entry points and multiple ways of engagement available to visitors.
- Provide physical and sensory access to all aspects of the program (including materials, presentations, and room set-up). (Reich, 2008)

The museum educators who lead drop-in programs are critical to their success. Like out-of-school time educators, they too need training in development and implementation of museum programs that are inclusive of people with disabilities. Program spaces also should be designed to be inclusive of museum educators who have disabilities. Areas of consideration include ramps that enable educators who use wheelchairs to access stages and other presentation platforms, storage spaces with enough room to navigate, and placement of materials at reachable heights.

Assistive materials—A few museums are creating backpacks or kits that provide parents of children with disabilities with tools and resources they can use to promote cognitive inclusion of their children in the museums' content and learning experiences. Although these materials are a separate resource intended only for children with disabilities, they also provide a form of social inclusion as they enable the family group (which includes individuals with and without disabilities) to continue to learn from and experience the museum together. The presence of such kits or backpacks can also be important for promoting the message to parents and children that the museum cares about and is interested in their specific needs. A noteworthy example is the backpack program that is in its pilot phase at the New Jersey Academy for Aquatic Sciences, Camden. The backpack provides parents of autistic children with tactile materials, flipbooks, images, and other resources they can use to lead their own programs that meet the needs of their individual child.

Technologies

CAISE AIG investigations located six digital media-based technologies that were specifically designed to create museum experiences that are inclusive of people with disabilities. These include assistive technologies designed for use by individuals with specific disabilities as well as technologies that reflect universal design and are intended for use by people with and without disabilities. In addition, six of the exhibitions cited above also feature inclusive digital media-based technologies.

Through the Signing Science handheld device, a virtual avatar provides ASL interpretation of science terms for zoo visitors. *Image courtesy Signing Science*

The identified assistive technologies provide interpretation in formats that are alternatives to the traditional text label, including audio tours and multimedia tours that include video or animation-based American Sign Language (ASL). Such assistive technologies can be beneficial for visitors with print-based disabilities for whom reading text is often a challenge. This includes visitors who are blind or have low vision, visitors who are dyslexic or have other reading-related disabilities, and visitors who are deaf (these visitors can have lower English reading levels as their first language is American Sign Language). A notable example of an assistive technology that provides an alternative form of communication is the *Signing Science* project (DRL-0754587) led by TERC. This project provides children who are deaf with handheld devices they can use to look up scientific terms in ASL while they explore a zoo with their parents or school group.

Findings from the evaluation of assistive technologies in museums demonstrate that these technologies can promote cognitive inclusion by providing alternatives to traditional text labels (Chin & Lindgren-Streicher, 2007; Giusti, 2000) and physical inclusion by providing assistance in the area of museum wayfinding (Giusti & Landau, 2004). Studies also demonstrate, however, that simply adding an assistive technology to an inaccessible exhibition is not sufficient for ensuring that people with disabilities will value and learn from their museum experience; the exhibition needs to be physically and cognitively inclusive as well (Friedman, 2000; Reich, 2009).

It is unknown whether digital media-based assistive technologies can lead to experiences that address the social inclusion of people with disabilities. Studies have shown that traditional audio tours can decrease social interactions among members of a visiting group unless such tours are specifically designed to promote social interactions (Woodruff et al., 2002). No study was identified that examined the social interactions of a group that included an individual with a disability who was using an assistive technology device.

A tactile computer interface provides a way for sighted and blind visitors to navigate through digital media-based interactives at the Museum of Science. *Image courtesy Museum of Science*

Only a few projects were found that featured technologies in museums that reflect the principles of universal design. These technologies generally provide multiple modes of communication (audio, text, images, and video) and a tactile interface for user input (such as push buttons as opposed to touchscreens). One example is a project at the Museum of Science, Boston, that studied a computer interface designed to be inclusive of visitors of a broad range of abilities and utilized across a number of interactive types. The study found that this interface yielded experiences that were physically inclusive and facilitated learning for visitors with and without disabilities. However, physical and cognitive inclusion was not always enough. If a visitor perceived that parts of the experience were inaccessible to him or her, this led to negative feelings about his or her experience at the museum (Reich, 2006a). This finding highlights the importance of the perception of inclusion for people with disabilities. The study also produced a set of guidelines for designing computer kiosks in museums that are inclusive of people with disabilities (Reich, 2006b). It should be noted, however, that when this computer interface was implemented in other museum exhibitions, it met with mixed success (Department of Evaluation and Research in Learning, 2007).

Organizational efforts

Through its investigations, the CAISE AIG identified at least seven science museums that appear to be addressing inclusion at the organizational level: the Chicago Children's Museum; the Lincoln Park Zoo, Chicago; the New York Hall of Science, Queens; the Museum of Life and Science, Durham, North Carolina; the Museum of Science Boston; the Science Museum of Minnesota, St. Paul; and the Pavilion of Knowledge—Ciência Viva in Lisbon, Portugal. For this report, organizational-level work in museums was defined as either 1) an established, institution-wide initiative that is aimed at developing an inclusive science museum learning experience, or 2) a record of sustained work in the area of inclusion over a long period of time.

The organizational-level work identified through this project provides a perspective on the pathways organizations take to institutionalize efforts toward inclusion. It is outside the scope of this report to judge the relative merit of these different pathways from the perspective of impacts on people with disabilities, or their relative effectiveness at achieving widespread or lasting change within an institution. However, there appear to be some common, cross-cutting themes, and stories captured from these organizations provide insights on possible avenues that may lead to lasting and effective change in the area of inclusion at the organizational level. As empirical studies have not yet examined inclusion at the institutional level, however, these themes should only be considered *plausible* pathways toward organizational-level inclusion, not *definitive* pathways.

Official inclusion plans

The identified organizations tend to have official inclusion plans and policies that museum staff members follow when developing and implementing educational experiences. A few have plans that extend across multiple departments or projects (including the Chicago Children's Museum, Lincoln Park Zoo, and Pavilion of Knowledge—Ciência Viva), while others develop plans that are specific to certain educational experiences (such as the Museum of Science, Boston, and the Science Museum of Minnesota). A notable example is the inclusion checklist developed by the Lincoln Park Zoo through its *Education Inclusion Initiative* (MA-02-05-0516-05). This checklist provides museum education professionals with information about how to design and implement a broad range of inclusive programs, including interpretation carts, lectures, and internships, among others.

Professional development

Organizations that address inclusion frequently offer professional development programs that train museum professionals in practices of inclusive informal science learning. Some programs specifically provide the museum educators who lead museum programs with knowledge and resources they can use when interacting with people with disabilities (such as programs led by the Lincoln Park Zoo, the Pavilion of Knowledge—Ciência Viva, and the Science Museum of Minnesota). Other programs provide exhibition professionals with information on ways to develop exhibitions that are inclusive of people with disabilities (such as the Museum of Science, Boston).

While none of these programs has been studied, evaluations of other professional development experiences from the field of science education and museums suggest that two goals are critical for professional development programs that promote inclusion—knowledge of inclusive practices and positive attitudes toward people with disabilities and inclusion. While prior museum professional development programs have focused almost exclusively on goals related to changes in knowledge (Hein, 2002, 2003), studies from the field of formal education demonstrate that changes in attitude can play a critical role in whether educators will take future actions toward inclusion (Pace, 2003; Seccombe, 2007).

Building upon prior work

CAISE AIG investigations reveal that a number of organizations have sought multiple grants over time to fund projects that promote inclusion of people with disabilities. Through these grant-funded projects, these organizations build upon prior work (both within and across institutions) in a way that leads to new technologies, practices, or knowledge that could advance the science museum field. Notable examples of such efforts include the New York Hall of Science's work on developing different styles of audio tours and interpretations for people who are blind or have low vision (ESI-9614858, ESI-9800577), and the work of the Science Museum of Minnesota (R25 RR15645, ESI-0407373), the Museum of Science, Boston (ESI-0307875, ESI-9814955, ESI-9909573, ESI-9626949, ESI-8652311), and the Museum of Life and Science, Durham (ESI- 9627030), all of which have worked to create exhibitions that reflect the principles of universal design and build upon each other's work. It is worth noting that all of these institutions were also involved in the ASTC Accessible Museum Practices initiative (ESI-9814917 and HRD-9906095).

Evaluation appears to be one mechanism institutions utilize to build upon prior work. A few (but not all) of the institutions have conducted formative and summative evaluation studies that have examined the effectiveness of the learning experiences they have developed for people with disabilities. Examples include studies of audio tours developed by the New York Hall of Science (Giusti, 2000; Giusti & Landau, 2004), and evaluations of multisensory, multimodal interactive exhibitions conducted at the Museum of Science, Boston (Karp & Leblang, 2004; Tisdal, 2007), and the Science Museum of Minnesota (Department of Evaluation and Research in Learning, 2007).

Involvement of people with disabilities in the work

There may be a link between sustained inclusive practices and the active involvement of people with disabilities in the work of the organization. Organizations that have sustained efforts at inclusive practices frequently involve people with disabilities in the work of the organization—as paid employees, advisors, consultants, volunteers, and visitors in evaluation studies. There is extensive evidence from multiple fields that contact with persons with disabilities often leads to a positive change in attitude toward disability (Yuker & Block, 1986). The summative evaluation of the ASTC Accessible Museum Practices initiative also found that the participating professionals thought their interactions with people with disabilities were among the most valuable aspects of the program (Hein, 2002, 2003). In addition, research from the field of formal education suggests that interaction with people with disabilities can be a critical element of professional development experiences that are aimed at promoting inclusive practices (Bishop & Jones, 2003; Kirch, 2005). It should be noted, however, that not all experiences with people with disabilities lead to positive changes. Negative impacts on attitudes toward disability have been found when people without disabilities interact with people with disabilities in settings where the difficulties of living with a disability are emphasized (Weisel, 1988). Therefore, it is important that the involvement of a person with disability highlight and utilize this individual's strengths and knowledge, and not be just a symbolic gesture.

Resources

The museum field has developed a number of resources that can assist those who are interested in implementing more inclusive practices in their institution. These resources include published guidelines, websites, and documents developed for individual projects or organizations that have the potential for broad applicability. These resources address many of the areas mentioned above, including the design of exhibitions, programs, and technologies. One of the most extensive resources is the ASTC's Accessible Museum Practices website, which provides accessibility information for a range of museum areas, including visitor services, publications, programs, and exhibitions (ASTC, 2008).

Notable exhibition resources include the *Smithsonian Guide for Accessible Exhibition Design* (Smithsonian Accessibility Program, 1996), *Everyone's Welcome* (American Association of Museums, 1998), the Museum of Science *Universal Design* website (Davidson, 2001), and *User Friendly: Hands-on Exhibits that Work* (Kennedy, 1997). The Sensory Trust in the United Kingdom has also developed resources that are specific to the design and development of sensory gardens. In addition, the Science Museum of Minnesota, the Museum of Science, Boston, and NISE Net each has created accessibility plans for individual exhibitions, which might have broader applicability.

Fewer resources provide guidance on design and implementation of science museum programs that promote physical, cognitive, and social inclusion. *Part of Your General Public is Disabled* (Majewski, 1987) is one noteworthy exception, which provides information about conducting accessible programs. While it does not specifically address inclusion in science museums, another potentially useful resource for program design is the book *Design for Accessibility*, which was published through a collaboration between the National Endowment for the Arts, the National Endowment for the Humanities, and the National Assembly of State Art Agencies (Siegel, Patterson, Bird, & Mathis, 2003). In addition, NISE Net[2], the Lincoln Park Zoo, and the Chicago Children's Museum each has created project or institution-specific resources that might be applicable to the programmatic work of other museums.

2 The NISE Net exhibit and program access guidelines are downloadable for free from *www.nisenet.org*.

There are a limited number of resources that provide information on the design of digital media-based technologies for use in museums. In most cases, museum professionals would be best served by examining guidelines that exist for generating inclusive media or websites, such as those created through the WSC Web Accountability Initiative. One resource developed for museums specifically is the guidelines for inclusive computer kiosks developed by the Museum of Science, Boston (Reich, 2006b).

Areas where a greater focus on inclusion is needed

While the field may have developed strategies and processes for creating inclusive science museum learning environments, some preliminary evidence suggests that these strategies and practices are not widespread. Prior surveys suggest that many science museum learning experiences may not be inclusive of people with disabilities. Tokar (2004) found that science museum exhibit professionals report low levels of accessibility for visitors with sensory disabilities in their institutions, with 32 percent of the survey participants stating that less than half of their exhibits are accessible for visitors who are deaf and 80 percent that fewer than half of their exhibitions are accessible to visitors who are blind. In addition, Allen-Greil (2007) found that over 85 percent of museum professionals surveyed did not use or consider accessibility guidelines when developing computer-based interactives. These findings suggest that more work is needed to make inclusion a common practice within science museums.

CAISE AIG investigations also reveal that there is a notable lack of research and evaluation studies that address the topic of inclusion in museums. Of the 31 projects identified, only 12 included people with disabilities in the remedial and/or summative evaluation. In many cases, summative evaluations were conducted for the project, but people with disabilities were not included in the final study population. A search of the literature identified only five empirical studies that were published in museum or education journals that address the inclusion of people with disabilities in science museum learning (Chin & Lindgren-Streicher, 2007; Cohen & Heinecke, 2004; Giusti & Landau, 2004; Rapp, 2005; Tokar, 2004). The absence of research in this area was further confirmed in the recent NRC report *Learning Science in Informal Environments* (National Research Council, 2009). This absence is notable as such work could make strong contributions to the field's understanding of inclusive practices.

Conclusion

Science museums are currently employing a variety of strategies to create informal science learning experiences that are inclusive of people with disabilities. These strategies include creating exhibitions, programs, and digital interactives that engage multiple senses; implementing programs and exhibitions led by museum professionals who are trained in inclusive practices; and providing visitors with disabilities with supplemental materials (such as technologies or kits) that enhance access to the general museum visit. As stated above, these strategies are infrequently implemented and not yet fully studied. Therefore, there is a need for *more widespread implementation and study of existing strategies for inclusion to determine their effectiveness.*

Museums also appear to be engaging in a number of common processes when developing inclusive learning environments. These processes are possibly linked to institution-wide or sustained efforts toward inclusion. They include developing inclusion plans that are specific to individual projects or organizations, offering professional development opportunities that are focused around the inclusion of people with disabilities in museums, building upon prior work when developing new inclusive experiences, and involving people with disabilities in the work of the institution. Further investigation is needed to learn more about whether, how, and why such practices may be effective at promoting efforts toward inclusion within institutions. Therefore, there is also a need for *greater study and adoption of processes that lead to institution-wide or sustained inclusion efforts*.

Recommendations

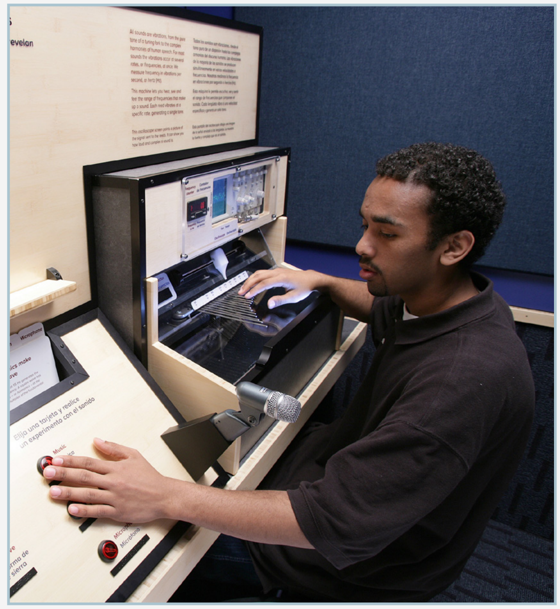
The CAISE AIG has identified specific recommendations for science museum professionals who are looking to expand their institutions' efforts toward inclusion. These recommendations are based on the theory of inclusion put forward in the introductory section of this report as well as practices of institutions that have organization-wide inclusion efforts. They include the following:

- Utilize the social model of disability and emphasize physical, cognitive, and social inclusion when developing, implementing, and studying inclusive learning experiences.
- Consider whether the museum will be perceived by people with disabilities as being inclusive of their needs.
- Offer professional development programs that include people with disabilities as trainers, enhance knowledge of inclusive practices, and promote positive attitudes toward inclusive practices and people with disabilities.
- Create inclusion plans that address the specific needs of individual projects or institutions.
- Involve people with disabilities in the work of making the museum more inclusive.
- Include people with disabilities in remedial and summative evaluation studies.
- Build upon existing strategies studied at other institutions when developing new experiences that promote the inclusion of people with disabilities.

The CAISE AIG also assembled specific recommendations for funders looking to advance the efforts of science museums in the area of inclusion. These recommendations are based on current practices and processes employed by museums when developing and implementing inclusive experiences, and also on the areas identified as requiring further work. Recommendations include the following:

- Require museums to include in their grant proposals one-page inclusion plans that state the actions the institution will take to ensure that the learning experience will be inclusive of people with disabilities. Providing access for people with disabilities is legally mandated for institutions that receive federal funding through Section 504 of the Rehabilitation Act, and for public institutions through Title III of the Americans with Disability Act.
- Encourage funding of empirical research studies that examine potential strategies for providing physical, cognitive, and social inclusion of people with disabilities in museums and practices that lead to institution-wide commitment in this area.
- Conduct Section 504 compliance reviews (such as those currently being carried out by NASA) to ensure that museums receiving federal funding are meeting the legal obligations of this law.
- Promote the adoption of existing strategies that have been developed with federal funding and have been shown to promote the inclusion of people with disabilities in science museum learning.
- Continue to support professional development programs that look to enhance museum professionals' knowledge and attitudes toward inclusive practices and people with disabilities.

In the Spotlight: *Wild Music*



The traveling exhibition *Wild Music: Sounds & Songs of Life* resulted from a partnership among the Association of Science-Technology Centers (ASTC), the Science Museum of Minnesota (SMM), and the Music Research Institute at the University of North Carolina at Greensboro, with funding from NSF (DRL-0407373). An exploration of the biological origins of the musical instinct, the exhibition began its national tour in 2007.

It was important to the *Wild Music* team that an exhibition about the deep roots and universality of music be broadly accessible and offer a rich and positive sonic experience. Planning an exhibition about music and sound would be a challenge, they knew. But from the beginning, they approached this as an opportunity—in particular, an opportunity to enrich the experience for visitors who are blind or have low vision.

Walter Waranka, an employment consultant and president of the Minnesota chapter of the American Council of the Blind who had earlier participated in an NSF-funded ASTC Accessible Museum Practices workshop, was engaged to serve as a member of the planning team. His regular participation helped maintain a focus on the experiences of people with disabilities. With Waranka's advice, the developers devised an array of strategies for interpreting sounds. These included

- Braille and acoustic labels. Standardized locations make these easy to locate.
- Tactile relief models. In one exhibit, for example, whale models are associated with buttons that activate different species' songs.
- Tactile diagrams. In an exhibit about animal vocalization, visitors can select a tactile sonogram of a bird, mammal, or insect song and insert it into a slot, activating an audio recording.
- Experiences of sound as vibration. A spectrum analyzer that works through vibrating metal reeds allows visitors to both feel and see that single sounds are often composed of several frequencies. In the exhibition's small theater, "bass shaker" speakers bolted under the seats let visitors feel low-frequency parts of the soundtrack, while limiting the spread of these hard-to-contain sounds into the rest of the exhibit space.
- Visual representations of sound. In a working model of a larynx, a fan blows low-pressure air through rubber flaps. By pulling on a control knob, visitors can stretch the flaps and bring them together, producing a sound that varies in pitch with the tension applied. Strobe LEDs help visitors see how vibrations make the sounds they hear—or to see sounds they can't hear.

Prototypes were critiqued by other consultants who had developed exhibits with people who are deaf and hard of hearing, then tested during a prototyping session attended by members of several Twin Cities groups that represent people who have personal and professional experience with disabilities.

In evaluation carried out after the exhibition was complete, visitors reported that they appreciated the tactile experiences and the presence of Braille and acoustic labels, even though most had not used these features themselves. Consultant Wally Waranka reported that *Wild Music* was the first exhibition he had felt able to navigate and enjoy almost entirely on his own—he even brought colleagues from the employment agency to visit, hoping to inspire their approach to workplace accommodations.

Web sites

www.wildmusic.org

http://www.exhibitfiles.org/wild_music_sounds__songs_of_life

http://www.exhibitfiles.org/pictures_of_sound

Photo courtesy Science Museum of Minnesota

Part 3: Media and Technology in Informal Science Education

Jeremy Price and Mary Ann Steiner

Media and technology are offering a range of individuals and groups, including those with disabilities, new and diverse ways of interacting with and participating in the discourses and practices of informal science learning. From television and radio to various software applications and the World Wide Web, media and technology offer learners flexibility in where, when, and how they engage with informal science learning experiences (National Research Council, 2009, p. 248). Multiple avenues for sharing and storing content also have resulted in a flexibility in the nature of content accessible to the general public—text, video, data visualizations, graphics, and simulations—all supported by networked data sets and content (NSF Task Force on Cyberlearning, 2008, p. 5). Networked technologies provide a rich venue for knowledge sharing and knowledge generation, allowing learners to identify their own starting points and then proceed at a comfortable speed, as well as providing opportunities to interact with others and potentially contribute to and participate in a larger inclusive community of interest (Barab, 2003; Bilda, Edmonds & Turnbull, 2007; Hoadley & Pea, 2002; Scardamalia & Bereiter, 1994).

Science museums and out-of-school programs typically incorporate movies, websites, and online and digital games into their experiences. In this chapter, rather than focusing on the settings in which media and technology are used, we look more broadly at social inclusion in the use of media and technology in ISE and highlight attributes of those efforts that seem to support inclusion.

The potential of media and technology

Broadcast television and radio are the largest sources for public information about science and technology due to the high percentage of people with televisions and radios in the home (National Research Council, 2009, p. 251). But increasingly, networked technologies—including cell phones, digital media players, digital readers, and other ubiquitous hand-held devices—have the potential to bring people into active learning roles as they customize their inquiries to meet personal learning goals, in the place and time of their choosing, using the technological tools and technology-supported roles that best fit their personal needs and interests. Networked technologies also have generated innovation in delivery of content and learning experiences as they mesh directly with more standard radio and television broadcasts—enabling learners to delve more deeply into personal interests as they tune into a program on a topic of prior interest, seek out medical or “how to” information at multiple websites, engage with other people who share an interest on blogs and community discussion boards, or visit an online gallery where they post strategies for game play and products of their inquiry (Jenkins, 2004).

Because of this connectivity and the ability to support public authorship, the possibilities and direction of broadcast media and technology are highly informed by one another. When broadcast media began to include additional web-based resources, a half-hour TV show was transformed into a kind of touchstone for a wide range of content, in multiple formats, with the potential to engage a community of interested individuals and extend and broaden the discussion. This relationship between the scheduled broadcast and “always-available” content is constantly evolving and deepening as each new technology is embraced by the public, as evidenced by the deeply interwoven websites, podcasts, games, and online networks available to learners.

Digital technologies also have expanded the media world one step further by providing tools and platforms and establishing lines of inquiry that take the public away from the familiar screen interface to explore the physical world around them with sensors, programs, actuators, and often simple craft materials or toys. Just as in web-based discussion and gaming, these experiences with hand-held computers, sensors, and actuators can be individual or social in nature with small groups or distributed networks of people competing or sharing findings and designs in the context of citizen science experiences, robotics competitions, and creative play networks (Buechley et al. 2006; Hammer et al 2008; Kafai et al 2009; Martin et al 2000; Melchoir et al 2006; Resnick & Rusk 1996). While often focused on young people's learning, these activities are also compelling for adults who participate in citizen science activities or showcase their electronics and craft designs in MakerFaires and similar events that are sometimes highlighted in "do-it-yourself" periodicals, such as *Make Magazine* (Torrey et al 2007).

Because of these characteristics, media and technology hold particular promise for inclusion. The learner's ability to choose when and how to access content sources removes some of the physical and logistical barriers to engaging in time- and place-constrained activities for all people, especially for those with disabilities. Much of the technology used in informal learning environments is also used in other aspects of daily life (e.g., televisions, telephones, computers, and hand-held devices), which creates a social connection to these tools as familiar sources of information and interfaces to the digital world. Design also has now moved from one professional designing experiences for a general public to a highly personalized relationship with media and technology, where learners both consume and construct information as they interact with the technology and with each other. This holds promise for development of inclusive science learning environments, as designers might uncover unexpected features of designs by attending more closely to how a wide range of people interact with them, including people with different abilities and disabilities. For instance, Allison Druin (2002) engages children in the full design process of education technologies for children; Carl Disalvo and colleagues (2008) engage communities in identifying and addressing issues of local concern through sensing technologies; and Ana Correia de Barros and Carlos Duarte (2009) visit people with disabilities in their homes to gain design insight as they observe the adaptations and creative problem solving employed around everyday activities.

Attributes of inclusive ISE media and technology

In its survey of the state of inclusive practices in ISE, the CAISE AIG carried out literature searches, reviewed NSF-funded projects, hosted a session at the July 2008 ISE Summit, consulted colleagues with experience in this area, and spoke with professionals in the field at several conferences. We included both educational broadcast media and digital technology in this review because it is difficult to draw strict boundaries between them in informal learning settings. We identified approximately 20 programs, organizational initiatives, and resources that represent exemplary practices in media and technology that promote physical, cognitive, and social inclusion (see appendix). These included

- **programs** that are models for inclusive design or practice, but not necessarily part of larger systemic efforts, like the Blind Audio Tactile Mapping System (BATS), mapping software which gives audio cues to provide geographical information to individuals with blindness or low vision
- **organizational-level initiatives** that originate from or affect an entire ISE organization or provider, resulting in or flowing from organizational attitudes or policies oriented to promoting inclusion or inclusive technology, media practices, and designs, like the Digital Talking Books guidelines published by the WGBH National Center on Accessible Media
- **resources** that assist the wider ISE field in meeting audience needs or identifying interesting opportunities, such as the NSF-funded DO-IT (Disabilities, Opportunities, Internetworking, and Technology) website.

Some organizations began with individual projects and have gone on to undertake organization-wide initiatives or develop resources useful for the wider field, while other efforts have been more limited and sporadic. Not all of the examples we cite address the three different aspects of inclusion—social, cognitive, and physical—to equal degrees, but all provide novel, interesting, and engaging ways into science that tend to draw audience members in irrespective of ability or disability.

The next section highlights key attributes of these programs, organizational initiatives, and resources that support inclusion in ISE for and enable people with all levels of experience and abilities to have multiple opportunities to learn within a socially, cognitively, and physically supportive and inclusive environment.

Multiple pathways into informal science learning

Media and technology provide means for a wide variety of people and populations to gain access to scientific content and discourse around scientific issues in informal learning environments.

In *WolfQuest*, a 3D, wildlife, simulation game, each player becomes a wolf in Yellowstone National Park, learning how to survive. *Image courtesy WolfQuest*

The NSF-funded *WolfQuest* online game (DRL-0610427), developed by the Minnesota Zoo and Educational Web Adventures, while it did not have inclusion as an explicit goal, it is nevertheless a good example of a media experience that provides an opportunity for inclusion. The engaging game play, focus on communications *and* content, and novel experiential aspect, can provide people with a range of disabilities access into the world of informal science learning. Studies have shown that, especially for individuals with disabilities, providing opportunities for success in one area, such as computer gaming, may translate into the belief that they can succeed in other areas—and this is especially true when there are coordinated efforts to intentionally foster inclusion (Reis, Neu, & McGuire, 1997).

The public television specials *Freedom Machines* (which first aired in 2004) and *Misunderstood Minds* (which first aired in 2002) exemplify another positive use of media, in this case by providing examples of people with disabilities as active participants in science and society, with the assistance of technology. (See Spotlight.) Such an approach provides a powerful and affirmative cognitive modeling opportunity for people with disabilities, demonstrating how others "like them" have been able to participate in science and society (c.f., Swain & French, 2000).

Multiple ways to enter into discourse with others

In addition to their motivational potential, described above, media and technology can be utilized in order to provide various ways for individuals to engage in meaningful discourse with others around informal science learning (Brown, Reveles, & Kelly, 2005; Lee & Fradd, 1998; Lemke, 2001), highlighting the social aspect of inclusion.

The NSF-funded DO-IT (Disabilities, Opportunities, Internetworking, and Technology) project (#9800324) from the University of Washington, for example, provides those with disabilities opportunities to connect around STEM online, through the sharing of a wealth of resources, and offline, through presentations, camps, workshops, and networking opportunities.

The exhibit *Walk on the Sun*, developed by the Design Rhythmics Sonification Research Lab (DRSRL) with funding from the National Aeronautics and Space Administration (NASA), provides a socially inclusive physical space that translates visual data into sound and is designed so that individuals with a range of disabilities can participate, learn, and interact in a specific space with other individuals with and without disabilities around science. (See Spotlight.)

Multiple ways to interact with technology and media

Social and cognitive aspects of inclusion rest upon an assumption that individuals with disabilities can physically interact with the learning environment. Guidelines for accessibility such as those found in Section 508 of the American Rehabilitation Act and in the WAI-WCAG (Web Accessibility Initiative-Web Content Accessibility Guidelines) provide a baseline for access, especially when the content is primarily textual in nature. The concept of "textual" refers to information primarily conveyed through words or numbers—printed, spoken, or otherwise displayed.

Some of these guidelines are insufficient, however, when the information conveyed is dynamic, interactive, and pattern-based, as is often the case in informal science learning environments. As such, novel ways have emerged in the field to address these concerns. We noted two approaches in the cases we examined: (a) allowing the individual or social group to control the flow of information through

In the Spotlight: *Freedom Machines*

Freedom Machines is a one-hour television special by filmmakers Jamie Stobie and Janet Cole, produced by Richard Cox Productions, San Francisco, with support from NSF (DRL-0003446), NEC Foundation, and other funders. The film premiered in 2004 and is still available, with related resources, through a website, *www.freedommachines.com*.

Through the stories of seven individuals, *Freedom Machines* demonstrates the power of technology to support physical, social, and cognitive engagement in the world as it stresses the importance of an inclusive stance toward the abilities of all people. Aimed at a wide broadcast audience, the program highlights the circumstances and achievements of individuals and those around them, providing a view into lives that are often hidden from public awareness—and validation for those who already are aware.

Each of the seven stories features assistive technology—the tools each individual uses to address daily needs and pursue learning goals—as well as ways the built environment creates unnecessary barriers. Designers, technologists, and advocates (often parents) interviewed in the film express excitement about the potential of technology to broaden people's worlds and share their vision of human-centered design that is useful to all—from curb cuts that ease travel by wheelchair, stroller, or skateboard to switch-free technology that reduces repetitive stress syndrome and at the same time allows people with limited dexterity to interact with computers.

In addition to focusing on ways technology supports learning, some of the stories feature people interested in and accomplished in the sciences, including Kent Cullers, a physicist who was born blind and leads the Search for Extraterrestrial Life Institute (SETI). Cullers makes the point that each person has something to contribute—and possibly a creative edge because of a different experience of the world.

This program explores opportunities for

- *physical inclusion* through universal design of spaces, assistive technology that aids navigation, and human-centered design
- *cognitive inclusion* through multiple modes of representation (visual, audio, and tactile) and computer-based tools that allow a variety of learners to cognitively engage with the content they are exploring
- *social inclusion* through tools and communication devices that allow individuals to participate in the world online and in person.

The program also emphasizes the reality that people have a range of abilities at different times in their lives—and that design in general can be human-centric and support development of human potential.

Web sites

www.freedommachines.com

www.pbs.org/pov/freedommachines/

technology and (b) offering multiple media streams and modes of representation.

Controlling the flow of information is a challenge to physical inclusion when technology and media interfaces are limited to keyboards, mice or trackballs, and touch screens, the traditional technology-human interface modalities. Such interfaces tend to exclude a number of individuals who may not easily be able to see or manipulate such controllers. DRSRL's *Walk on the Sun* is an exception, allowing individuals to utilize hand-held transducers to manipulate the projection of the sun's surface in the exhibition, essentially manipulating the dataset being projected. Being able to use broad strokes and natural movements means users do not need a high degree of fine motor skills to participate. The Wii Remote ("Wiimote") and the accelerometer found in the Apple iPod touch or iPhone, among other hand-held devices, provide similar functionality. A useful paper available from the inclusion-oriented game design company Fire Hose Games (Glinert, 2008) outlines important dimensions of design of inclusive technology- and game-based interfaces: learnability, simplicity, efficiency, and aesthetics.

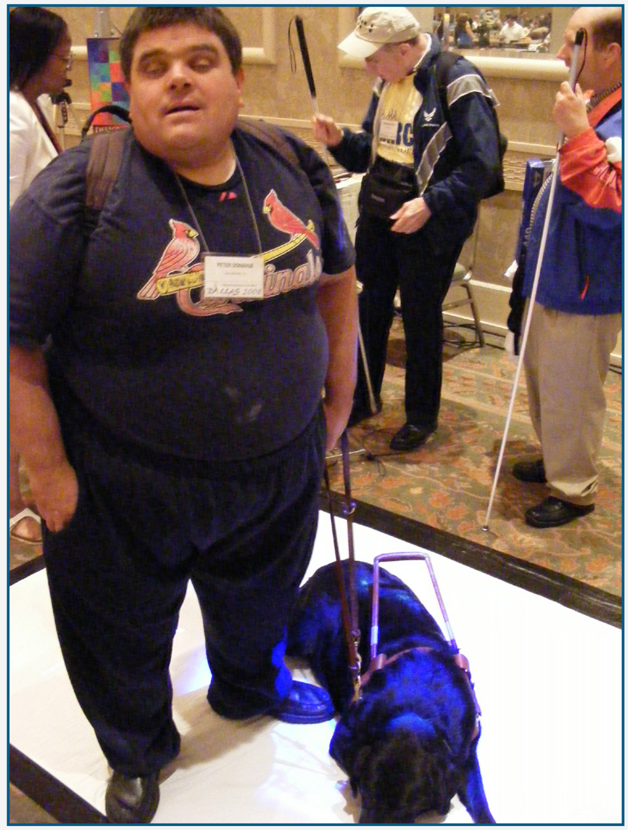
Multiple media streams and multiple modes of information representation are leveraged by inclusive media and technology. Most of the projects we reviewed are oriented directly to supporting the experience of individuals who are blind or have low vision by providing an auditory stream to accompany text or other visual information. Such implementations also provide ways for individuals with learning disabilities, who may find reading printed text to be a barrier to participating in informal science learning, to access textual information as well. The NSF-funded Digital Talking Book (DTB) standard for description of science content (#0435663), highlighted by the National Center for Accessible Media (NCAM) at WGBH, provides the technical framework for implementing a multimedia representation of texts. The same standards underlie the National Instructional Materials Accessibility Standards for accessible instructional materials and textbooks in formal education (National File Format Technical Panel, 2008), spearheaded by the research and development group CAST.
For non-textual content, Fire Hose Game's *AudiOdyssey* is an example of inclusive game play for both sighted and non-sighted players that makes use of both visual and auditory cues. Audio maps—such as the University of North Carolina's BATS project (Blind Audio Tactile Mapping System) and Open Sound New Orleans (a collaborative sound map of the city)—offer interesting designs for alternate media representations of spatial information. The Fish Farming component of the Museum of Science, Boston's *Making Models* exhibition provides auditory representations of graphs to provide alternate representations of dynamic numeric information. Similarly, DRSRL's *Walk on the Sun*, mentioned earlier, uses tones from the Spanish Gypsy scale to represent the color and intensity of the pixels in the projection. In addition, the exhibit's hand-held transducers provide tactile feedback by vibrating in users' hands.

It is important to highlight that there are potential drawbacks with the improper or excessive use of multimedia, which can result in exclusion rather than inclusion. Evaluation revealed that the Fish Farming component of the *Making Models* exhibition flashed graphics at a dangerous frequency, for example, and even caused one visitor with an existing condition to go into a seizure. Individuals with sensory integration disorder or other related conditions can become disorganized with a bombardment of multimedia, making learning difficult if not impossible, irrespective of the individual's interest in the topic. Following the guidelines laid out in Section 508 and providing media-free or quiet zones in technology-based exhibitions or public spaces as well as breaks or intermissions can help provide a more inclusive environment.

Scaffolding for including a diversity of people in scientific discourse

Media and technology can also help to provide cognitive scaffolding that enables a range of diverse

In the Spotlight: *Walk on the Sun*



Walk on the Sun was developed by Design Rhythmics Sonification Research Lab in collaboration with the University of California–Berkeley Space Science Laboratory and Christa McAuliffe Planetarium with support from NASA. Since 2007, this exhibit has appeared at science museums and other settings nationwide, enabling a wide range of users—including wheelchair users, those who are blind or deaf, or have low-vision or learning disabilities—to engage physically, cognitively, and socially with imagery and data from NASA solar research.

In a 5-feet by 5-feet space, an image of the surface of the sun is projected on the floor. Two controllers allow users to select data they want to explore. As they move over the projection, their movements are mapped onto the projection and accompanied by musical notes from a 36-note Spanish Gypsy scale according to the pixel set over which they are hovering. Transducers provide vibration-based tactile feedback to users' hands.

Walk on the Sun is *physically inclusive* because it provides a representation in visual (video projection of the sun's surface), audio (pixels as notes on the Spanish Gypsy scale by color and intensity), and tactile (vibrations by hand-held transducers) formats. The projection of the sun's surface is also large enough for a variety of visitors to experiences, either through their hands or their bodies, allowing for the use of wheelchairs.

The exhibit is *cognitively inclusive* because the multiple modes of representation (visual, auditory, and tactile) allow for inclusion of a variety of learners so they may engage with the exhibit content. The kinesthetic nature of the exhibit also allows for the cognitive inclusion of a number of visitors who may have trouble gaining meaning just by looking at or listening to words and images.

The exhibit is *socially inclusive* because the multiple media streams allow for participation and discussion by a number of visitors who may not normally have access to the content (including those who are blind, deaf, or wheelchair users). The projection space itself fosters interactions among visitors, regardless of disability or learning style, as they move around the space and manipulate the controllers to move the satellite cameras around the sun.

These features enable a broad range of visitors to gain confidence through their participation while they engender a sense of inquiry. The combination of the controllers and the kinesthetic nature of the experience facilitate engagement for those who would prefer game-like and active learning to kinesthetically passive learning, such as reading or listening. While *Walk on the Sun* was designed specifically to provide access for individuals with sensory-based disabilities (primarily blind or low-vision visitors, secondarily deaf visitors through the use of the transducers), it has been shown to provide opportunities for inclusion for a larger range of visitors, including wheelchair-users and others with a range of learning disabilities and styles.

Web site

www.drsrl.com

Photo courtesy *Walk on the Sun*

individuals and social groups to engage with the concepts and content embedded within informal learning settings (CAST, 2008; Baloian, Luther, & Sánchez, 2002). An example is the Fish Farming component of the *Making Models* exhibition, which provides a controlled and structured experience that requires the user to first run a simulation without manipulating any variables, then prompts and cues the user to try changing other variables. In addition, there is a "note-taking" feature, which allows visitors to consider the interactions of variables rather than trying to keep all the information in their heads.

Despite the potential, we found that the capacity of media and technology to provide cognitive scaffolding—examples of questions, models of processes, and a sense of structure in open inquiry—has been largely overlooked and underutilized in informal science education.

Conclusions

From this review of inclusive practices in media and technology in ISE, we learned the following:

Inclusive practices can be found in existing ISE media and technology experiences, including some that were not designed with inclusion in mind. These exemplary practices provide multiple pathways into ISE, multiple ways to engage in discourse with others around ISE, multiple ways to interact with media and technology, and scaffolding for including a diversity of people in scientific discourse. There are very few intentional and integrated approaches to inclusion in ISE media and technology, however.

Existing technologies can be leveraged to foster inclusive informal science learning environments. Innovative uses of technology can lead to inclusion in unexpected and novel ways that don't necessarily require new designs and costly assistive technologies.

Explicit focus on examples of cross-fertilization in technology—in terms of what transferred well from daily use to applications in ISE learning environments—might help others to shift their professional mindset to think in new ways about environments, people, and what we know and expect of technology.

Evaluating experiences with inclusive audiences can help to identify inclusive strategies for technology use that can then be shared through professional networks and begin to spread through the ISE field.

Rapid technological change and diversification can unintentionally result in the exclusion of individuals unless there is a concerted emphasis on inclusion in the design and evaluation of technologies. To ensure the widest range of people are engaging in informal science experiences with media and technology both personally and in social groups, it is important to be sure they are included in the design process individually and in social groups and as makers of solutions or testers of them, so that effective design and support elements are evident.

When making design decisions and considering aspects of evaluation, it is important to remember that each person is an individual, and there is a great deal of diversity both *between* and *within* disability groups. Technologies that are inclusive for some or even most individuals—with or without disabilities—may exclude other individuals. Towards this end, it is important to remember Hehir's description of the "supercrip" phenomenon (2002) and to shape one's expectations accordingly. Any failure of the technology or media to foster inclusion is not the fault of the individual or individuals, but of the technology or media and its design, even if it serves to foster inclusion for others.

It is important to recognize that social inclusion for people with disabilities does not just "happen" by providing access to media and technology. Mark Warschauer (2003) notes that as technology *access* becomes more ubiquitous, a focus on *technological literacies* is necessary in order to support inclusion. These literacies include supporting the visitor or learner—with or without disabilities—in the skills necessary to maximally benefit from using the technology-based environment. Such support can be built into the design of the technologies themselves, through add-on tutorials and guided tours, or by the assistance of well-trained and caring staff.

Recommendations

In summary, whether online or offline, learning in media settings like those described here is supported by user familiarity with the platforms for conveying content (technologies that are in daily use) and the wide range of accessible narratives and topics that generate or nurture interest. For motivated learners, recognition and opportunities to showcase their work or to engage in meaningful exchanges might deepen participation. For some who become contributors, sharing content they have generated in knowledge-building communities allows social connection and recognition around ideas of relevance, resulting in deeper and deeper commitment to the process. While the existence of technology and the access it provides to content doesn't necessarily mean people will engage in science learning, media and technology provide powerful environments with rich potential to support science learning for a diversity of individuals, including those with disabilities.

Recommendations for the ISE field:

- *Include audiences in the design and evaluation process* in order to push the quality of practice. In future projects norms could include: (a) including people with a wide range of abilities and disabilities in the conceptualization and design process and (b) developing partnerships with organizations that already serve different ability and disability groups to ensure long-term relationships and broaden the pool of individuals involved in the process.
- *Support intentional and integrated approaches to inclusion in technology and media practices through education, dialogue, standards, and requirements*. Such an approach can be instrumental and important in allowing designers and developers to approach inclusion through a balanced physical-cognitive-social inclusion model. Requiring that inclusion be a focus of the evaluation process is one way to approach this challenge. Developing standards similar to NIMAS for creating technology-based inclusive label copy and building these standards into the national cyberlearning infrastructure platform (NSF Task Force on Cyberlearning, 2008) would also help to generate broader interest in this endeavor.

Recommendation for ISE funders:

- *Support the development and sharing of models* of inclusive practices in ISE media and technology so that good ideas can spread and be more fully tested. This could be facilitated through online communities and databases and workshops and sessions at existing conferences to focus shared practice. All of these traditional formats along with a centralized call to attend to the issue could help to establish a critical mass of people interested and supported in pursuing and sharing this line of inquiry.

While the CAISE AIG struggled to identify a set of exemplary inclusive projects ISE media and technology projects and practices that addressed inclusion systematically, our hope is that the report will generate dialogue that begins to uncover more of the existing successes and challenges. Existing forums such as DO-IT, at the University of Washington, may be able to add informal learning experiences to their formal education base. In addition, InformalScience.org, a professional community around general informal science learning interests, and ExhibitFiles.org, an online community of exhibition practitioners, might provide venues for sharing resources and discussions around inclusive practice. Ideally these web-based community sites would collaborate to introduce professionals from different fields to relevant information and dialogue partners. With this centralized community and targeted discussion around the topic, both the community and those who fund informal science learning experiences could begin to see the consolidated efforts of the field and to identify and support productive next steps.

Part 4: Inclusion in ISE Youth and Community Programs

Ellen Rubin

Youth and community programs focus on people as active learners full of potential and possibility. For many, such programs are welcoming environments that treat people—often young people of school age—holistically, aiding in the development of social and content skills, whether it be sports, arts, or academics. Out-of-school youth programs typically provide plenty of opportunities for adult-child and child-child relationships to form. This kind of environment has the potential to be highly supportive of the inclusive model for informal science education (ISE)—but the realization of this potential is often hindered by norms and negative attitudes that our society has developed over time.

In this chapter, I offer observations and reflections about the current state and potential of youth and community programs based on information-gathering by the CAISE AIG and on my own personal and professional experience over many years working in and with the ISE field.

The vision and challenge

Under the heading "Diversity and Equity," the NRC's report *Learning Science in Informal Environments* states that "an important value of informal environments for learning science is being accessible to all" (2009, p. 209). As others have pointed out, "Socioeconomic, cultural, ethnic, historical, and systemic factors, however, all influence the types of access and opportunities these environments afford to learners" (Heath, 2007).

When we speak about people with disabilities, it is not always enough for an experience to be *accessible*. In an *inclusive* model, the attention is on how the environment works for individuals and groups, rather than simply ability to participate. Programs that serve a range of individuals in order to promote science learning must enable all participants to physically interact and perceive the space, cognitively engage with the materials, and socially interact with one another.

To identify examples of inclusive youth and community informal science experiences is a complicated task. These programs occur in a wide variety of settings and locations within an equally diverse set of organizations—including after-school programs, national youth-serving organizations, large drop-in programs at community centers, Scouts, and clubs that focus specifically on science learning (in addition to museums, as noted in an earlier chapter). Although a program may offer STEM features, that may not be immediately apparent. Science activities may not be labeled as "science" or may be single components of larger programs with diverse offerings. As a result, program web sites and other outreach efforts rarely highlight science content.

In addition, the design of youth and community programs varies, as do their policies and strategies for inclusion. Programs may be geared towards youth of all ages, as well as adults and seniors. Some programs embrace full inclusion, meaning participants with and without disabilities enjoy and are involved in ISE activities together. Others provide separate programs specifically for participants with disabilities; these programs may be further divided by disability type.

Further complicating the task of identifying inclusive ISE youth and community programs is the fact that there may be only sporadic participation by people with disabilities—and how such participants are identified and their needs addressed may vary as well. There are programs that occasionally include one or two young people with disabilities within a group of younger non-disabled participants, for example. Drop-in programs may provide STEM-related activities, but the lack of consistent attendance may be a factor determining participant interest and continued engagement. Also, it is possible to find organizations that are open to the public, where students with hidden disabilities (those that are not obviously identifiable[1]) are included in activities, initially without staff awareness.

Out-of-school STEM education for people with disabilities

With these considerations as background, the CAISE AIG identified a small number of inclusive youth and community programs with a STEM focus. Drawing as well on the literature and on our other experiences working in and with such programs, I offer these observations:

Out-of-school STEM learning opportunities are scarce

There is a general lack of out-of-school learning opportunities, including those with STEM content. According to the Afterschool Alliance's 2009 survey, America After 3PM, 15 million children are left alone and unsupervised after school because of a lack of such opportunities.

Finding inclusive youth and community STEM learning opportunities can be difficult

Even youth and community programs that do offer informal science experiences do not always inform potential attendees that they are inclusive, and potential participants with disabilities who are interested in exploring STEM activities may miss an opportunity to gain important exposure to STEM learning. If a program indicates in its advertising literature or website that the program welcomes participants of all abilities, a prospective participant will know that s/he will be welcomed.

Physical, attitudinal, and social barriers to participation still exist

Despite legislation that protects against it, people with disabilities still experience discrimination on a regular basis. Many people with disabilities have experienced the humiliation and discomfort of being turned away due to physical, attitudinal, or social barriers.

In some cases, settings are not physically accessible. Participants with more obvious disabilities may even be unable to get in the door and all too frequently are sent away. This includes people with physical disabilities who may use wheelchairs, walkers, crutches, and/or braces. It also includes people with sensory disabilities (those who are blind or have low vision and who may use white canes, guide dogs, human guides, large print, Braille, or electronic formats) and people who are deaf or hard of hearing who use sign language, sign language interpreters, CART, amplification, open captioning and/or hearing instruments.

Programs may not comply with federal requirements, often claiming budgetary limitations. in some cases, young people with disabilities are not willing to participate unless there is some indication that they will be accepted as true members of the group.

1 Hidden disabilities may include but are not limited to: learning disabilities, attention deficit disorder, attention deficit-hyperactivity disorder, emotional disabilities, diabetes, asthma, heart conditions, and epilepsy.

Multiple factors make it difficult to identify and understand individual needs

If an individual knows someone of a particular disability group, they are unprepared to accept that their prior knowledge of that specific disability may not manifest itself in exactly the same way in another individual with seemingly the same disability. When program staff observe people with disabilities, they may incorrectly label the disability and make assumptions about the needs, interests, skills, and talents of the individual. If group leaders know someone of a particular disability group, they might assume that all members of that group have the same needs. This can lead to an unwillingness to recognize or accept that their prior knowledge of that specific disability may not manifest itself in exactly the same way in another individual with seemingly the same disability. Such tacit labeling has the potential to exclude, discriminate, and provide inappropriate means to be inclusive.

In after-school programs, information about a student's disability may not be known by the group leaders due to confidentiality rules. Often, parents do not disclose their child's disability because they are afraid that if the disability is known, the child will not be accepted or may be treated differently. If hidden disabilities like diabetes, asthma, and heart disease are unknown to responsible adults, group leaders may encourage children to participate in activities that may exacerbate their disabilities and have potentially disastrous consequences. Parents should be supported and encouraged to share information about their children's disability to ensure the child's safety. This might be achieved as part of Individualized Educational Plan (IEP) process that takes place through the child's school. During IEP meetings, parents might be alerted to the benefits of informing out-of-school-time programs of their children's disability status and how doing so may ultimately serve their children.

For those parents who choose not to place their children in settings where they may be ostracized or misunderstood, programs that meet specific needs of children with disabilities may be acceptable alternatives. However, the goal of such programs should be to provide learning experiences that develop skills that ultimately prepare those children for future inclusive programs.

Confronting "ableist" attitudes

Thomas Hehir (2002) defines ableism as "the devaluation of disability" that "results in societal attitudes that uncritically assert that it is better for a child to walk than roll, speak than sign, read print than read Braille, spell independently than use a spell-check, and hang out with nondisabled kids as opposed to other disabled kids." There is considerable evidence that unquestioned ableist assumptions are limiting the inclusion of children with disabilities and are a cause of inequities. As is the case with racism and sexism, progress toward equity is dependent first and foremost on the acknowledgment that ableism exists in our society. Ableist assumptions and practices are still deeply embedded both in school and youth and community programs.

Nevertheless, the disability rights movement is systematically working to dispel the ravages of ableism. "Nothing about us without us," a slogan adopted by the disability rights movement, refers to the importance of respecting the wisdom, experience, and expertise of people with a wide variety of disabilities in the creation of policies that impact the disabled community (Charleton, 1998).

Norman, Caseau, and Stefanich (1998) surveyed 189 science teachers who taught elementary, middle, and high school, and undergraduates studying science education about their attitudes towards and knowledge of students with disabilities. Responses revealed that the majority of the teachers did indeed have students with disabilities in their classrooms, but that they did not feel adequately prepared to teach them. More teachers felt prepared to teach students with learning disabilities than students with motor or sensory disabilities. Teachers also reported negative attitudes and misconceptions about students with disabilities. For example, over half of the teachers surveyed agreed that disability categories were too often used as an excuse for failure, and over 40 percent felt that students with disabilities should not be given unrealistic goal expectations because they would inevitably be frustrated in their search for employment (p. 137). The result of this survey, the authors concluded, was a clearly defined barrier: classroom teachers are not adequately prepared to meet the needs of students with disabilities in general education classrooms (p. 143).

The trend described in the research surveying school teachers is perhaps even more pronounced in out-of-school youth programs. Group leaders are typically college or even high school students who are supervised by graduate students or professionals who may not have adequate background in working with youth with disabilities. The staff turnover in such programs tends to be high due to limited funding and difficulty keeping group leaders who have other educational and personal responsibilities.

The attitudes of teachers, parents, group leaders, and even peers can have profound impacts, both positive and negative, on students' experience in community environments. It is essential that teachers, group leaders, and staff at any organization creating an inclusive program understand what is necessary to make youth and adults with and without disabilities comfortable and welcomed, in addition to fostering interdependence among students.

Conclusions

According to 4-H, "Inclusion means that people with disabilities have the same opportunities for involvement in meaningful and satisfying experiences as afforded other segments of the population" (Stumpf, Henderson, Luken, Bianleschki, Casey, 2002).

The trend today is toward providing supports to increase inclusive opportunities within all programs open to the public. For most individuals, the elimination of physical and social barriers reduces the need for special programs only for people with disabilities. Inclusion, however, involves more than just placing people with disabilities into a group. It involves social interaction and physical integration, as well as cognitive understanding.

What approach will improve outcomes of community programs while increasing the numbers of students with disabilities engaging in informal science? As noted by the Kids Included Together (KIT) program (see below), "Inclusion is about systems change. It is about creating a culture that will enhance the community's capacity to embrace diversity."

To be truly inclusive, the learning environment must be welcoming to people with disabilities. Inclusion means altering the environment more than forcing the person with a disability to change.

Providing support expresses an acceptance of a person and his or her abilities and helps the individual participate at his or her level of independence.

Staff development for youth and community program leaders will help improve outcomes. This must include enhancing comfort with science inquiry, increasing understanding of the importance of inclusion, and educating staff about the skills and talents of people with disabilities.

On a daily basis, people with disabilities face physical, attitudinal, and/or cognitive barriers, which must be grappled with in order to achieve goals, making for a population of excellent creative problem solvers. If people with disabilities with expertise in STEM are employed in ISE, they can and will serve as role models for participants with and without disabilities as well as assisting, modeling, and providing positive images for staff members and students.

In the Spotlight: *Science Seminar*

The Science Seminar, an ongoing after-school science program conducted in PS 110, a public school on New York City's Lower East Side, is an exemplary inclusive out-of-school-time program, which provides children with disabilities with roles that allow them to draw on their strengths rather than reinforcing their weaknesses. Children with and without disabilities learn together through hands-on, inquiry-based science activities.

The Science Seminar meets once a week in the school where students are familiar and comfortable in the physical space. The program's target size is 15 students, but the group is frequently larger. Participants are recruited equally from the school's three fifth-grade classes – a gifted class, a general education class, and a special education class. The special education class includes students with learning disabilities, emotional disabilities, ADD/ ADHD, and social and physical disabilities. The students have diverse cultural, ethnic, and racial backgrounds, and the majority come from families who are low income.

Each session begins with a short hands-on science challenge. When given the opportunity to self-select groups, the students try to recruit peers from the gifted and talented class with the idea that they will be the most successful at the challenges. However, each year, a few months into the program, it becomes evident that in fact the students from the special education class appear to be better problem-solvers, and the general education students begin recruiting those students. This creates a definite change in the group dynamics, as students from the special education class move from being second-class citizens to being the cool science kids, with a different self-image and level of self-esteem.

All students learn that everyone in the group has developed good problem-solving skills and therefore the students are more likely to work together interdependently, regardless of the academic grouping they are placed in during in school learning. This shift is possible because all students are comfortable with the physical space, able to cognitively engage with the material, and encouraged to interact socially.

When it began in 1993 as a before-school program called Sunrise Science, funding came from the highly motivated instructor who initiated it. Ultimately, the school's Parent-Teacher Association provided funds for materials and buses for trips to informal science sites. Additionally, museum educators, researchers, and other informal science educators have made resources available to the group.

Each year, former students return to PS 110 to volunteer as coaches for the new students in the Science Seminar. Some of them have presented at National Science Teachers Association conferences. At one NSTA conference, some of the students noted these features of Science Seminar that had been important to them:

We like to do more hands-on activities.
We want to do harder experiments that are challenging to us.
We want to do something different every week.
Having a smaller group was an advantage.
We didn't have to wait long for people to complete their tasks.
We got more projects and accomplishments done faster.
Also having science coaches from previous years was a great assistance.

Why did they join Science Seminar? Here's what they said: "We loved science and wanted a challenge. We wanted to do different kinds of science.We'd be with our friends and fellow classmates while learning, working together, and having fun."

Photo by Maryann Stimmer

References

Abraham, M., Griffin, D., & Crawford, J. (1999). Organisation change and management decision in museums. *Management decision, 37*(10), 736-751.

Afterschool Alliance. (2009). *America After 3PM*. Retrieved from http://www.afterschoolalliance.org/AA3PM.cfm

Allen-Greil, D. (2007). *Survey report: Guidelines for designing computer-based interactives in museums*. Washington, DC: Smithsonian Institution.

Al-Mohamed, D. (2006, January 5, 2006). *Accessible currency: myth vs. fact*. Retrieved September 9, 2009, from http://www.acb.org/washington/wc070105.html

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

American Association of Museums. (2000). *Code of ethics*. Retrieved August 5, 2009, from http://www.aam-us.org/museumresources/ethics/coe.cfm

Argyris, C., & Schon, D. (1995). *Organizational learning II: Theory, method, and practice*: Prentice Hall.

Association of Science-Technology Centers. (2008). Association of Science-Technology Centers web site. Retrieved April 10, 2008, from http://www.astc.org/resource/access/index.htm

Baglieri, S., & Knopf, J. H. (2004). Normalizing difference in inclusive teaching. *Journal of Learning Disabilities, 37*(6), 525-529.

Baloian, N., Luther, W., & Sánchez, J. (2002). Modeling educational software for people with disabilities: theory and practice. In *Proceedings of the fifth international ACM conference on Assistive technologies* (pp. 111-118). Edinburgh, Scotland: ACM.

Barab, S.A. (2003). An introduction to the special issue: Designing of virtual communities in the service of learning. The Information Society, (19) 197-201.

Barnes, C. (2003). What a difference a decade makes: Reflections on doing 'emancipatory' disability research. *Disability and Society*, 18(1), 3-18.

Batsche, G. M., Kavale, K. A., & Kovaleski, J. A. (2006). Competing views: a dialogue on Response to Invervention. *Assessment for Effective Intervention*, 32(1), 6-19.

Beer, M., & Nohria, N. (2000). *Breaking the code of change*. Boston, MA: Harvard Business School Press.

Bishop, A., & Jones, P. (2003). 'I never thought they would enjoy the fun of science just like ordinary children do'-- Exploring science experiences with early years teacher training students and children with severe and profound learning difficulties. *British Journal of Special Education, 30*(1), 34-43.

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

Borun, M., Dristas, J., Johnson, J. I., Peter, N. E., Wagner, K. F., Fadigan, K., et al. (1998). *Family Learning in Museums: The PISEC Perspective*. Philadelphia, PA: The Philadelphia-Camden Informal Science Education Collaborative.

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

Brown, B. A., Reveles, J. M., & Kelly, G. J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning. *Science Education, 89*(5), 779-802.

Buechley, L., Elumeze, Nwanua, & Eisenberg, M. (2006). *Electronic/ computational textiles and children's crafts*. Paper presented at the Interactive Design and Children Conference 2006 in Tamere, Finland.

Candlin, F. (2003). Blindness, art and exclusion in museums and galleries. *The International Journal of Art and Design Education, 22*(1), 100-110.

CAST. (2008). Universal Design for Learning (UDL) Guidelines - Version 1.0. Retrieved July 30, 2009, from http://cast.org/publications/UDLguidelines/version1.html.

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

Charlton, J. (1998). *Nothing about us without us*. Berkeley, CA: University of California Press.

Chin, E., & Lindgren-Streicher, A. (2007). Designing experiences that enable all visitors to learn. *The Informal Learning Review* (85).

Cohen, O., & Heinecke, A. (2004). Scenes of Silence: An exhibition to break down mental prejudices. *Visitor Studies Today, VII*(III), 11-15.

Correia de Barros, A. & Duarte, C. (2009). Assistive Devices—Stroke Patients' Design. In *Proceedings of the 2009 ACM SIGCHI Conference on Creativity and Cognition*, 79-86. Berkeley, CA: ACM.

Davidson, B. (2001). *Universal Design (Accessibility)*. Retrieved December 30, 2003, from http://www.mos.org/exhibitdevelopment/access/

Davidson, B., Heald, C. L., & Hein, G. (1991). Increased exhibit accessibility through multisensory interaction. *Curator, 34*(4), 273-290.

Department of Evaluation and Research in Learning. (2007). *Remedial Evaluation: Wild Music*. St. Paul, MN: Science Museum of Minnesota.

DiSalvo, C., Nourbakhsh, I., Holstius, D., Akin, A. & Louw, M. (2008). *The Neighborhood Nets Project: A case study of critical engagement and creative expression through participatory design*. Paper presented at the Participatory Design Conference.

Druin, A. (2002). The Role of Children in the Design of New Technology. *Behaviour & Information Technology*, vol. 21, no. 1, 1-25. U.K.: Taylor and Francis Ltd.

Dudley-Marling, C. (2004). The social construction of learning disabilities. *Journal of Learning Disabilities, 37*(6), 482-489.

Eisenberg, M., Elumeze, N., Buechley, L., Blauvelt, G., Hendrix, S. & Eisenberg, A. (2005). The homespun museum: Computers, fabrication, and the design of personalized exhibits. In *Creativity and Cognition*, Proceedings of the 5th conference on Creativity & cognition, London: ACM, 13-21.

Elmore, R. (1995). Getting to scale with good educational practice. *Harvard Educational Review, 66*(1), 1-26.

Fleischer, D., & Zames, F. (2001). *The Disability Rights Movement*. Philadelphia, PA: Temple University

Press.

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

Fuchs, D., & Fuchs, L. S. (2006). Introduction to Response to Intervention: What, why and how valid is it? *Reading Research Quarterly, 41*(1), 93-99.

Fullan, M. (2007). *The new meaning of educational change* (4th ed.). New York, NY: Teachers College Press.

Gamson, W. (1998). Social movements and cultural change. In M. G. Giugni, D. McAdam & C. Tilly (Eds.), *From Contention to Democracy*. Lanham, MD: Rowman and Littlefield Publishers, Inc.

Gersten, R., & Baker, S. (1998). Real world use of scientific concepts: Integrating situated cognition with explicit instruction. *Exceptional Children, 65*(1), 23-36.

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

Giusti, E. (2000). *Summative evaluation of audio guide for blind and low vision at the New York Hall of Science*. New York, NY: New York Hall of Science.

Giusti, E., & Landau, S. (2004). Accessible science museums with user-activated audio beacons (Ping!). *Visitor Studies Today, 7*(3), 16-23.

Glinert, E. (2008). The human controller: Usability and accessibility in video game interfaces, MIT Masters Thesis. Retrieved December 4, 2009, from http://www.firehosegames.com/?s=human+controller

Griffin, J., Baum, L., Blankman-Hetrick, J., Griffin, D., Johnson, J., Reich, C., et al. (2007). Optimizing learning opportunities in museums: The role of organizational culture. In J. Falk, L. D. Dierking & S. Foutz (Eds.), *In principle, in practice: Museums as learning institutions*. Lanham, MD: Alta Mira Press.

Hammer, E., Lauwers, T., Bernstein, D., Nourbakhsh, I., & DiSalvo C., (2008). Robot diaries: Broadening participation in the computer science pipeline through social technical exploration. Menlo Park, California. In *Association for the Advancement of Artificial Intelligence spring symposium on using AI to motivate greater participation in computer science '08 Chicago*.

Hamner, D., Hall, A. C., Timmons, J. C., Boeltzig, H., & Fesko, S. (2008). Agents of change in the disability field: bridge-builders who make a difference. *Journal of Organizational Change Management, 21*(2), 161-173.

Hargreaves, A., & Fink, D. (2006). *Sustainable Leadership*. San Francisco, CA: Jossey Bass/Wiley.

Hargreaves, A., & Fullan, M. (Eds.). (2009). *Change wars*. Bloomington, IN: Solution Tree.

Hargreaves, A., & Shirley, D. (2009). *The Fourth Way: The Inspiring Future for Educational Change*. Thousand Oaks, CA: Corwin.

Hehir, T. (2002). Eliminating ableism in education. *Harvard Educational Review, 72*(1), 1-33..

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

Hein, G. (2003). *Accessible practices: Interactive exhibits final summary evaluation report 1999-2002*.

Cambridge, MA: Program Evaluation and Research Group at Lesley University.

Hoadley, C. M., & Pea, R. D. (Eds.) (2002). *Finding the ties that bind: tools in support of a knowledge-building community*. NY: Cambridge University Press

Jaeger, P. T., & Bowman, C. A. (2005). *Understanding disability: Inclusion, access, diversity and civil rights*. Westport, CT: Praeger Publishers.

Janes, R. R., & Conaty, G. T. (Eds.). (2005). *Looking reality in the eye: Museums and social responsibility*. Calgary, Alberta: University of Calgary Press.

Jenkins, H. (2004). The cultural logic of media convergence. *International Journal of Cultural Studies, 7*, 33-44.

Jeon, Y., & Haider-Markel, D. P. (2001). Tracing issue definition and policy change: An analysis of disability issue images and policy response. *Policy Studies Journal, 29*(2), 215-231.

Karp, J., & Leblang, J. (2004). *Making Models: Summative evaluation report.* Cambridge, MA: Program Evaluation and Research Group at Lesley University.

Kelley, T., & Littman, J. (2001). *The art of innovation* (1st ed.). New York, NY: Doubleday.

Kennedy, J. (1997). *User friendly: Hands-on exhibits that work.* Washington DC: Association of Science-Technology Centers, Inc.

Kirch, S. A. (2005). Inclusive science education: Classroom teacher and science educator experiences in CLASS workshops. *Inclusive science education, 105*(4), 175-196.

Kotter, J. P., & Cohen, D. S. (2002). *The Heart of Change: Real Stories of How People Change Their Organizations*. Boston, MA: Harvard Business School Press.

Lee, O. (1999). Equity implications based on the conceptions of science achievement in major reform documents. *Review of Educational Research, 69*(1), 83-115.

Lee, O., & Fradd, S. H. (1998). Science for all, including students from non-English-language backgrounds. *Educational Researcher, 27*(4), 12-21.

Leinhardt, G., Crowley, K., & Knutson, K. (Eds.). (2002). *Learning conversations in museums*. Mahwah, NJ: Lawrence Erlbaum Associates.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of Research in Science Teaching, 38*(3), 296-316.

Majewski, J. (1987). *Part of your general public is disabled: A handbook for guides in museums, zoos, and historic houses* (2nd ed.). Washington, DC: Smithsonian Institution Press.

Martin, F., Mikhak, B., Resnick, M., Silverman, B., & Berg,R. (2000). To mindstorms and beyond: evolution of a construction kit for magical machines, *Robots for kids: exploring new technologies for learning*, Morgan Kaufmann Publishers Inc., San Francisco, CA.

Mastropieri, M. A., Scruggs, T. E., & Magnusen, M. (1999). Activities-oriented science instruction for students with disabilities. *Learning Disabilities Quarterly, 22*(4), 240-249.

McCaffrey, R. (2007). The effect of healing gardens and art therapy on older adults with mild and moderate depression. *Holistic Nursing Practice, 21*(2), 79-84.

McDermott, R. P. (1996). The acquisition of a child by a learning disability. In S. Chaiklin & J. Lave (Eds.), *Understanding practice: Perspectives on activity and context*. New York, NY: Cambridge University Press.

McDermott, R. P., & Varenne, H. (1995). Culture as "disability". *Anthropology and Education Quarterly, 26*(3), 324-348.

McLeskey, J., & Waldron, N. (2006). Comprehensive school reform and inclusive schools. *Theory into practice, 45*(3), 269-278.

Melchoir, A., Cohen, F., Cutter, T., & Leavitt T. (2005). More than Robots: An evaluation of the FIRST Robotics Competition, participant and institutional impacts. Waltham, M.A.: Brandeis University.

Moussouri, T. (2007). Implications of the social model of disability for visitor research. *Visitor Studies, 10*(1), 90-106.

National File Format Technical Panel. (2008, November 19). *National instructional material accessibility standard (NIMAS) report*. Retrieved July 30, 2009, from http://nimas.cast.org/about/report.

National Organization on Disability. (2004). *N.O.D./Harris 2004 survey of Americans with disabilities*. Washington, DC.

National Research Council. (2009). *Learning science in informal environments: People, places and pursuits*. Committee on Learning Science in Informal Environments. Philip Bell, Bruce Lewenstein, Andrew W. Shouse, and Michael A. Feder, Editors. Board on Science Education, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Science Foundation. (2004). *Women, minorities, and persons with disabilities in science and engineering: 2004*. Washington, DC: National Science Foundation, Division of Science Resources Statistics.

NSF Task Force on Cyberlearning. (2008). *Fostering Learning in the Networked World: The Cyberlearning Opportunity and Challenge.* Arlington, VA: National Science Foundation. Retrieved July 30, 2008, from http://www.nsf.gov/pubs/2008/nsf08204/index.jsp.

Norman, K., Caseau, D., & Stefanich, G. P. (1998). Teaching students with disabilities in inclusive science classrooms: Survey results. *Science Education, 82*, 127-146.

Ogawa, R. T., Crain, R., Loomis, M., & Ball, T. (2008). CHAT-IT: Toward conceptualizing learning in the context of formal organizations. *Educational Researcher, 37*(83-95).

Ogawa, R. T., Loomis, M., & Crain, R. (2008). Institutional history of an interactive science center: The founding and development of the Exploratorium. *Science Education*, 270-292.

Onol, I. (2008). Tactual explorations: A tactile interpretation of a museum exhibit through tactile art works and augmented reality. In H. J. Chatterjee (Ed.), *Touch in Museums* (English ed., pp. 91-106). New York, NY: Berg Publishers.

Pace, D. (2003). Increasing awareness and understanding of students with disabilities. *Academic Exchange*, 205-214.

Pacific Science Center. (2009). *ASTAR Survey Responses*. Seattle, WA.

Palincsar, A. S., Collins, K. M., Marano, N. L., & Magnusson, S. J. (2000). Investigating the engagement and learning of students with learning disabilities in guided Inquiry science teaching. *Language, Speech, and Hearing Services in Schools, 31*, 240-251.

Palincsar, A. S., Magnusson, S. J., Collins, K. M., & Cutter, J. (2001). Making science accessible to all: Results of a design experiment in inclusive classrooms. *Learning Disabilities Quarterly, 24*(1), 15-32.

Poria, Y., Reichel, A., & Brandt, Y. (2009). People with disabilities visit art museums: an exploratory study of obstacles and difficulties. *Journal of Heritage Tourism, 4*(2), 117-129.

Rapp, W. H. (2005). Inquiry-based environments for the inclusion of students with exceptional learning needs. *Remedial and Special Education, 26*(5), 297-310.

Reich, C. (2005). *Universal design of interactives for museum exhibitions*. Unpublished master's thesis, Lesley University, Cambridge, MA.

Reich, C. (2006a). *Universal design for computer interactives for science museum exhibitions.* Paper presented at the National Association for Research in Science Teaching Annual Meeting, San Francisco, CA.

Reich, C. (2006b, March 1, 2006). *Universal design of computer interactives for museum exhibitions*. Paper presented at the Museums and the Web 2006: Proceedings, Toronto.

Reich, C. (2008). *Guidelines for the universal design of public programs for science museums.* Boston, MA: NISE Network.

Reich, C. (2009). Addressing deaf visitors with an American Sign Language multimedia tour. *ASTC Dimensions* (July/August), 14-15.

Reis, S. M., Neu, T. W., & McGuire, J. M. (1997). Case studies of high-ability students with learning disabilities who have achieved. *Exceptional Children, 63*(4), 463-479.

Resnick, M. & Rusk, N. (1996). The Computer Clubhouse: Preparing for life in a digital world. *IBM Systems Journal, 35*(3-4), 431-439.

Roberts, L. (1997). *From Knowledge to Narrative: Educators and the Changing Museum*. Washington, DC: Smithsonian Institution Press.

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.

Scanlon, D. (2003). Proceed with caution: RTI. *CEC Today, 10*(2), 14.

Scardamalia, M. & Bereiter, C. (1994) Computer support for knowledge-building communities. *The Journal of the Learning Sciences* (1993-1994) 265-283.

Scruggs, T. E., Mastropieri, M. A., & Boon, R. (1998). Science education for students with disabilities: a review of recent research. *Studies in Science Education, 32*, 21-44.

Seccombe, J. A. (2007). Attitudes towards disability in an undergraduate nursing curriculum: The effects of a curriculum change. *Nursing Education Today, 27*, 445-451.

Siegel, B., Patterson, W., Bird, K., & Mathis, A. (Eds.). (2003). *Design for accessibility: A cultural administrator's handbook*. Washington, DC: National Assembly of State Arts Agencies, National Endowment for the Arts, and National Endowment for the Humanities.

Smith, S. R. (2001). Distorted ideals: The ‘problem of dependency’ and the mythology of independent living. *Social Theory and Practice, 27*(4), 579-599.

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

Spence, C. (2007). Making sense of touch: a multisensory approach to the perception of objects. In E. Pye (Ed.), *The power of touch: handling objects in museum and heritage contexts* (pp. 45-61). Walnut Creek, CA: Left Coast Press, Inc.

Spence, C., & Gallace, A. (2008). Making sense of touch. In H. J. Chatterjee (Ed.), *Touch in museums* (pp. 21-40). New York, NY: Berg.

Story, M. F., Mueller, J. L., & Mace, R. L. (1998). *The universal design file: Designing for people of all ages and abilities*. Raleigh, NC: The Center for Universal Design.

Stumpf, M., Henderson, K., Luken, K., Bianleschki, D., and Casey II, M. (2002). 4-H programs with a focus on including youth with disabilities. *Journal of Extension, 40*(2). Retrieved from http://www.jpe.org/joe/2002april/a4.html.

Swain, J., & French, S. (2000). Towards an Affirmation Model of Disability. *Disability & Society, 15*(4), 569.

Tisdal, C. E. (2007). *Summative Evaluation of Star Wars: Where Science Meets Imagination*. St. Louis, MO: Tisdal Consulting.

Tokar, S. M. (2004). Universal design in North American museums with hands-on science exhibits: A survey. *Visitor Studies Today, 7*(3), 6-10.

Torrey, C., McDonald, D. W., Schilit, B. N. and Bly, S. (2007). How-to pages: Informal systems of expertise sharing. In *Proceedings of the Tenth European Conference on Computer-Supported Cooperative Work*. ECSCW ‘07. 391-410. Retrieved July 30, 2008, from http://cristentorrey.squarespace.com/storage/TorreyECSCW2007.pdf

Trent, S. C., Artiles, A. J., & Englert, C. S. (1998). From deficit thinking to social constructivism: A review of theory, research, and practice in special education. *Review of Educational Research, 23*, 277-307.

U.S. Department of Education, Office of Civil Rights. (2005) The Civil Rights of Students with Hidden Disabilities Under Section 504 of the Rehabilitation Act of 1973. Retrieved from http://www.ed.gov/about/offices/list/ocr/docs/hq5269.html.

Vaughn, S., Bos, C. S., & Schumm, J. S. (2007). *Teaching Exceptional, Diverse, and At-Risk Students in the General Education Classroom*. Boston, MA: Allyn & Bacon.

Waldrop, J., & Stern, M. (2003). *Disability Status: 2000*. Retrieved December 30, 2003, from http://www.census.gov/prod/2003pubs/c2kbr-17.pdf

Warschauer, M. (2003). Technology for social inclusion: Rethinking the digital divide. Cambridge, MA: MIT Press.

Weisel, A. (1988). Contact with mainstreamed disabled children and attitudes toward disability: a multidimenstional analysis. *Educational Psychology, 8*(3), 161-168.

Wing, A., Giachritsis, C., & Roberts, R. (2007). Weighing up the value of touch. In E. Pye (Ed.), *The Power of*

Touch (pp. 31-44). Walnut Creek, CA: Left Coast Press, Inc.

Woodruff, A., Aoki, P. M., Grinter, R. E., Hurst, A., Szymanski, M., & Thornton, J. D. (2002, April, 2002). *Eavesdropping on electronic guidebooks: Observing learning resources in shared listening environments*. Paper presented at the Museums and the Web, Boston, MA.

Yuker, H. E., & Block, J. R. (1986). *Research with the attitudes towards disabled persons scales*. Hempstead, NY: Center for the Study of Attitudes Toward Persons with Disabilities at Hofstra University.

Appendix

Following is information about exhibitions, programs, media and technology experiences, and other resources compiled by the CAISE Access Inquiry Group in the course of preparing this report.

Science museum exhibitions

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
The Audio Tour Access Project **New York Hall of Science, Queens** NSF (#9614858 and #9800577), NEC Foundation of America	Audio tour of existing exhibits at the New York Hall of Science.	P,S	Access consultant advised on development and selection of exhibits and creation of audio tour. People who are blind participated in the summative evaluation.
BioQuest Woods **Museum of Life and Science, Durham, North Carolina** NSF (#9627030)	Graphics designed with large type and high contrast. Tactile models. Buttons and levers can be operated with closed fist. Signs and activities designed for wheelchair users; language customized for people with cognitive disabilities, closed captioning of video; and audio labels that describe experiences and read labels.	P,S,C	Accessibility advisory board consisted of persons representing all major disabilities.
Buehler Enabling Garden **Chicago Botanical Gardens, Glencoe, Illinois**	Design elements make plants accessible for people with mobility disabilities (raised beds, paved surfaces, wall gardens, and hanging plants) and perceptible for blind or low vision visitors (tactile guides, bright plants, water fountains, and plants that have a pleasant texture). Accompanying programs are designed for people with disabilities, including older adults.	P,S,C	

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Dinosphere: Now You're in Their World **The Children's Museum of Indianapolis, Indiana** Lilly Endowment, Scott A. Jones Foundation, and other private funders	Enhanced access for visitors with mobility-related disabilities. Stools at interactives make child-height experiences easier to use for adults. Gooseneck mounts allow for height adjustments at some interactives . Main messages delivered through multiple formats.	P,S,C	Access consultant and VSA Arts involved in development of exhibit materials and designs.
Dogs: Wolf, Myth, Hero & Friend **Los Angeles County Museum of Natural History, California** NSF (#0072921)	Exhibit featured tactile models and some auditory interpretations. Heights, clearances for wheelchairs, and strength requirements were strongly considered. Content included relationship between dogs and people with disabilities.	P	People with disabilities were involved as advisors, participated in front-end and formative evaluation focus groups, and delivered educational content about helping dogs.
Fragrance Garden **Brooklyn Botanic Garden, New York**	Braille labels and guiding hand-rails. Height-adjustable potting tables. Assistive listening devices.	P,S	
Lerner Garden of the Five Senses **Coastal Maine Botanical Gardens, Boothbay, Maine** Institute of Museum and Library Services (IMLS)	Fully accessible plantings, plant collections, and architectural features to excite the senses of touch, taste, smell, sound, and sight (water wall, wind sculpture, sound chamber, and reflexology labyrinth). Visual and audible orientation, guide curb, tactile signs and maps, and audio signs. Designed to stimulate interest in gardening in persons with disabilities.	P,S,C	
Listen: Making Sense of Sound **Exploratorium, San Francisco, California** NSF (#0307925)	Design features increase disability access, include use of tactile interface for computer kiosks and audio labels. In one component, person who is blind takes viewers on a auditory tour of his commute.	P,S	A person who is blind assisted with development of some components.

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Making Models **Museum of Science, Boston** NSF (#9909573)	Each component features audio, text, and image-based interpretations. Interactive experiences engage multiple senses including touch, sight, and audio.	P,S,C	Exhibition development guided by community consultants with personal and professional expertise in disabilities. People with disabilities tested exhibits during formative and summative evaluation.
Making Natural History Exhibits Multisensory **Museum of Science, Boston** NSF (#8652311)	Early example of universal design in exhibits. Each diorama interpreted using text labels, audio, smell, and tactile models. Multisensory interactive experiences added to engage visitors more deeply with content. Labels written to ensure that text was easy to understand for Deaf visitors whose first language is ASL. Summative evaluation found that people with disabilities learned from the exhibition and experience was improved for people without disabilities.	P,S,C	Main exhibit developer and project PI was a wheelchair user. People with other disabilities were involved in project as advisors. Children with disabilities were invited to museum to participate in formative evaluation of exhibit components.
Messages **Museum of Science, Boston** NSF (#9626949)	Most interactives feature audio, text, and image-based interpretations. Emphasis on interactive experiences that engage wide range of senses. Developed new push-button interface accessible for people who are blind.	P,S,C	Main exhibit developer and project PI was a wheelchair user. People with other disabilities were involved in project as advisors.
Secrets of Aging **Museum of Science, Boston** NSF (#9814955)	Most interactives feature audio, text, and image-based interpretations. Emphasis on interactive experiences that engage wide range of senses and are inclusive of older adults who may have disabilities. Guidelines developed for design of accessible exhibitions for older adults. Topics related to disability and universal design addressed in exhibition.	P,S,C	Blind, access consultant served as core exhibit team member. Older, disabled adults served on advisory committee. People with disabilities tested interactive experiences during formative and summative evaluation.

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Star Wars: Where Science Meets Imagination **Museum of Science, Boston** NSF (#0307875)	Each component features audio, text, and image-based interpretations. Interactive experiences engage multiple senses. Multimedia tour with virtual American Sign Language interpreter.	P,S,C	Project team included two consultants with disabilities and exhibit design experience. Disabilities organizations involved in formative and remedial evaluation.
Tissues of Life **Science Museum of Minnesota, St. Paul** National Institutes of Health (#R25 RR15645)	Audio labels and tactile models	P,S,C	
Wild Music: Sounds & Songs of Life **Science Museum of Minnesota, St. Paul; ASTC; University of North Carolina at Greensboro School of Music** NSF (#0407373), NEC Foundation of America	Bi-lingual text (English and Spanish), audio labels, and Braille. Multisensory interactive, tactile diagrams, and computer interactives with tactile interfaces..	P,S,C	A person who is blind served on the exhibition team. People with disabilities participated in formative and remedial evaluation.
TEAMS 2 **Lead Institution Montshire Museum of Science, Norwich, Vermont** NSF (#0000589)	Collaborative worked together to produce a series of exhibits for smaller science centers that featured elements that reflected universal design.		
Rocket Model **New York Hall of Science, Queens** NSF (#0421973)	Tactile scale model of a rocket on display outside and visible through window. Also provides audio and visual interpretations related to the rocket and the history of rocketry.		A consultant who is blind helped to develop this exhibit.

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Touch exhibits **New York Aquarium**	Touch exhibits throughout the aquarium designed for people with disabilities.	P,S	
Launchpad **Science Museum, London**	Evaluators conducted study with students with disabilities and their teachers to explore how Launchpad exhibition could be improved. Changes were made to supplementary programs, including staff-interpreted experiences.	P,S	Students with disabilities were able to provide feedback on the design of experiences for other students with disabilities.
Wild Animal Park, Zoological Society of San Diego, California	For people with and without disabilities, accommodations include courtesy shuttle, informational pamphlets, show and railway scripts for people who are deaf and hard of hearing, map highlighting most accessible routes and walkways.		Kids Included Together (KIT) supported development.

Programs

Autism programming **New Jersey Academy for Aquatic Sciences, Camden**	Provides parents with advance planning books, backpack with tactile materials to help them guide their child's experience in the aquarium.	P,S,C	Some pilot testing of the materials.
Autism programming **Pacific Science Center, Seattle, Washington**	Number of initiatives planned to increase inclusion for children with autism. A survey suggests that parents want inclusive programs (81%), as well as quiet spaces in the museum and early access during non-peak times.	P,S,C	Early survey of parents with children who have autism.
Autism programming **Science Museum of Minnesota, St. Paul**	Summer camp program works to be inclusive of students with autism. Instructors learn strategies for not singling students out and support their learning.	P,S,C	

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Play for All Initiative **Chicago Children's Museum, Illinois** Supported by multiple foundations	Committee of CCM staff dedicated to increasing museum's accessibility and inclusiveness. Projects include improving Universal Design of exhibits and programs, Museum Kits, staff trainings, and developing accessible, inclusive workshops. Team also helped develop CCM's Access & Inclusion Position Paper.	P,S,C	Group partnered with multiple Chicago organizations, Chicago Mayor's Office. Individual advisors with disabilities also involved.
Senior Environmental Experiences **Ramapo College of New Jersey, Mahwah** NSF (#0407280)	Internet videoconferencing is used to connect seniors at community centers and extended care facilities with environmental experts at the Meadowlands Environment Center. Information provided via technology and structured specifically for this population meets the cognitive goals of the program, while the physical and social aspects of the program are achieved by conducting the activities in the natural environments where seniors congregate.	P,S,C	

Professional Development

Creating Laboratory Access for Students in Science Project **Wright State University, Dayton, Ohio** NSF (#0435658)	Science faculty collaborated with teacher educators and disability services personnel to teach science educators how to make their laboratories and field experiences accessible in order to effectively include students with physical, sensory, and learning disabilities in grades 7–16.	P,S,C	

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Education Inclusion Initiative **Lincoln Park Zoo, Chicago, Illinois** Institute of Museum and Library Services	Docent trainings on how to work with people with disabilities, multisensory educational materials, lectures with descriptive language and multimodal supports, working dog content, hiring interns with disabilities, etc.	P,S,C	A special education consultant performed most of the work. People with disabilities and parents of children with disabilities were invited to serve as advisors.
Kids Included Together (KIT) **San Diego, California**	KIT has established connections to aid local youth organizations to learn why inclusion is critical for the growth of everyone in the community. KIT addresses issues related to immediate concerns of staff members as they extend programs to serve increased numbers of participants with and without disabilities in inclusive programs.		
NISE Net Exhibits and Programs **Museum of Science, Boston and numerous partner organizations** NSF (#0532536)	Guidelines developed for the universal design of museum exhibits and programs in NISE Net collection. Design elements include audio, text, and image-based interpretations, tactile computer interfaces, easy to read graphics, stools, and wheelchair-accessible activities.	P,S,C	Reviewed design of the exhibits during formative evaluation and will be involved during summative evaluation. Education experts with disabilities were core members of a design charrette and involved in universal design for public programs guidelines.
Professional development program **Pavilion of Knowledge—Ciência Viva, Lisbon, Portugal**	On-going training with museum educators and exhibition designers, to increase institution's ability to engage disabled visitors; 3D scale model of museum provides way-finding for blind visitors. Visitors touch model and activate audio interpretation of areas of the museum.	P,S,C	The institution works with a number of disability organizations and advisors.

***P = Physical, S = Social, C = Cognitive**

Media/Technology

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Applied Design and Assistive Technology Program, Hampshire College Lemelson Center, Amherst, Massachusetts	Design program focused on tools for anyone. Review technologies that developed as assistive technologies and are now broadly used such as tape recorders, curb cuts, and remote controls.	P	
Archimedes Hawaii, University of Hawaii, Honolulu	Strives to create solutions that provide general access to science and mathematics. Aims to provide all children with equal opportunities and education to enter scientific and technical careers.		People with disabilities serve as advisors
AudiOdyssey, Singapore-MIT GAMBIT Game Lab, Massachusetts Institute of Technology, Cambridge, Massachusetts	Experimental computer game with major audio component designed to be accessible to both visually impaired community and mainstream gamers. Positive social impact through inclusion.	P	
Blind Audio Tactile Mapping System (BATS), Computer Science Department and Ancient World Mapping Center, University of North Carolina, Chapel Hill	Tool to make maps accessible to people who are blind through directional environmental sounds and tactile feedback, then audible information when significant landmarks are identified.	P	
Digital Talking Books, National Center for Accessible Media, WGBH, Boston, Massachusetts NSF (#0435663)	Research program that seeks to develop technology that provides full access to diagrams through description.	P,S	

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
EARTH+: Dynamic Earth Science Exploration for Blind Learners, NASA Science For Educators	Makes NASA satellite photos and data accessible to blind students as they navigate around a picture and "see" it using sound cues about features in the picture. Developed by team from NASA Johnson Space Center, University of Maryland, Baltimore Campus/ Goddard Earth Science and Technology Center, and University of Puerto Rico.	P	University of Puerto Rico team members from FILIUS Institute of Disabilities and Rehabilitation Research
FireHose Games, Cambridge, Massachusetts	MIT spin-off making video games with positive social impact. Thesis on design principles, The Human Controller: Usability and Accessibility in Video Game Interfaces, available at www.firehosegames.com/thesis/		
Game Accessibility SIG, International Game Developer's Association	Online learning community that focuses on positive impact and game accessibility as part of game development.	P,S,C	
Intelligent Total Access System (iTASK) Archimedes Hawaii, University of Hawaii, Honolulu	Alternative way to perform keyboard, mouse, and/or monitor functions of information technology devices. Incorporates Integration Manager and Natural Interaction Processor (IMNIP). Applications include Visual TAS for blind computer users and Total Access Game Interface (TAGI) for accessible game consoles.	P,S,C	People with disabilities serve as advisors.
Keen Guides, Keen Guides, Inc., Arlington, Virginia	Using video, GPS, and latest accessible technologies, creates downloadable tours in several accessibility modalities (closed captioning, sign language and cued speech). Visitors can download tours or use pre-loaded devices at participating cultural venues.	P	

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Open Sound New Orleans, New Orleans Jazz & Heritage Festival and Foundation Inc. www. opensoundneworleans.com	Visual map on a web site with embedded sounds.	P	
PING! Touch Graphics and the New York Hall of Science NSF (#0421973)	Cell-phone tour provides navigation and interpretation of museum's galleries for blind or low vision visitors. Using menus visitors select a destination to visit and receive auditory directions. The exhibit makes a chirping sound so that visits can audibly determine direction.	P,S,C	Consultant with personal and professional expertise in blindness involved in development. System tested with visitors who were blind and had low vision.
SAM Animation, Tufts University Center for Engineering Education and Outreach, Medford, Massachusetts NSF (#0511979)	Enables children to create stop-action animations, allowing for multiple means of expression and, applied to science learning, increasing potential for children to continue work outside of school.	S,C	
Signing Science TERC, Cambridge, Massachusetts NSF (#0754587)	TERC has developed a handheld ASL dictionary children can use to look up and learn ASL science terms in the context of zoos or museums.	P,S,C	Extensive studies with students who are Deaf in the classroom. Planning grant included students of Deaf children in a zoo.
Sun Walk, Design Rhythmics Sonification Research Lab, Lee, New Hampshire NASA	Projection of real solar data onto floor that responds with light and sound changes as people explore the image. (See In the Spotlight, page 43.)	P,C	Individuals with disabilities involved fairly extensively in formative evaluation.
The We Do Program, LEGO Education	Programming via simple, drag-and-drop software and larger easy-to-manipulate interfaces allows children to build and program without reading.	P,S,C	Children who were not literate helped with testing.

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
WolfQuest, Minnesota Zoo/ eduweb NSF (# 0610427)	Engaging and social game play, active and supportive online community, online chats with biologists.	S,C	

Broadcast and Film

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Freedom Machines Richard Cox Productions NSF (#0003446)	Public television program and outreach campaign that highlights use of adaptive technology and involvement in STEM learning. (See In the Spotlight, page 41.)	P,S,C	People with disabilities are subjects of the story
Misunderstood Minds WGBH, Boston, Massachusetts www.pbs.org/wgbh/ misunderstoodminds	Public television special, web site, and multimedia library for abled people to learn what it is like to struggle with attention, reading, writing, or math.	C	People with disabilities are subjects of the story

Resources

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
DO-IT (Disabilities, Opportunities, Internetworking & Technology), College of Engineering, University of Washington, Seattle NSF (#9800324)	Database of STEM resources, research, programs, and discussion forums designed to support engagement of people with a wide range of disabilities in STEM learning. DO-IT scholars are loaned computers, software, adaptive technology and supplied Internet access, mentoring, and other support.	P,S,C	People with disabilities involved
Inclusive Communities, PBS Parents www.pbs.org/parents/ inclusivecommunities	Web site for parents and caregivers of children with and without disabilities, addressing topics such as inclusive education, assistive technology, autism, augmentative communication, and learning disabilities.	P,S,C	Developed with input from families with children with disabilities

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Intentionally Inclusive 4-H Club Programs	4-H is a national organization that has made a commitment to include youth and volunteers with disabilities as program participants. This program has the mission of purposefully creating accessible environments and engaging communities to address the needs of people with disabilities.	P,S,C	
NASA: Goddard Space Flight Center. **Greenbelt, Maryland**	The NASA Goddard Equal Opportunity Programs Office ensures complete accessibility for all programs, activities, and facilities and provides accessible materials for people with disabilities. NASA has also supported the production of tactile books by author Noreen Grice with Braille, large print, and raised line tactile drawings.	P,S,C	
National Center for Blind Youth in Science (NCBYS), National Federation of the Blind Jemigan Institute, Baltimore, Maryland NSF (#0533182)	Resource for youth conferences, mentors, career development, speakers, and programs for youth and parent.	P,S,C	
The National Federation of the Blind (NFB) **Baltimore, MD**	NFB offers summer programs that focus on hands-on inquiry-based science, an approach that is particularly advantageous for people who are blind or low vision. NFB also maintains the National Center for Blind Youth in Science Web Portal, a clearinghouse of information and resources regarding blind youth and STEM subjects and careers.	P	Mentors who are blind, low vision, or sighted guide participants through the science activities and serve as role models.

***P = Physical, S = Social, C = Cognitive**

Project, institution, funding	Key features/design highlights	Inclusion?*	Involvement of persons with personal and professional experience with disabilities
Special Education for Students with Disabilities (SESD), National Science Teachers Association (NSTA) **Arlington, Virginia**	National and regional NSTA conferences provide ongoing meetings and workshops for science educators who work in both schools and community programs that include students with disabilities.		People with disabilities are committee members.
Teaching Accessible Science, Perkins School for the Blind, Watertown, Massachusetts	Resources, materials, and activities for teachers who work with blind students.	P	Best practices developed with Perkins students who are visually impaired.
Top Ten Tips for Buying Toys, Toys R Us	Tips for toys with multi-sensory appeal, self-expression, adjustability, and social inclusion, developed by National Lekotek Center.	P,S,C	

***P = Physical, S = Social, C = Cognitive**

Extra text from part 3 to be added to appx

Exemplary programs and resources

Following is a sampling of exemplary youth and community STEM learning programs and resources. The sidebar (opposite?/p. ##) describes Science Seminar, an exemplary program based in New York City that serves as a model for inclusion in science programming. Additional programs and projects are listed in the appendix.

Creating Laboratory Access for Students in Science Project (CLASS) was conducted at Wright State University in Dayton, Ohio, with funding from NSF's Division of Human Resources Development (#0435658). The program's collaborative approach is a positive example not only for in-school programs, but for out-of-school programs as well. The science faculty collaborated with teacher educators and disability services personnel to teach science educators how to make their laboratories and field experiences accessible in order to effectively include students with physical, sensory, and learning disabilities in grades seven through sixteen. Encouraging faculty with diverse backgrounds to collaborate resulted in enhancing and facilitating the inclusion of students in science learning. This type of program provides the skill set for science faculty to consider the most effective means of meeting students' needs. Cross-disciplinary efforts would increase STEM learning and benefit group leaders working in programs inclusive of people with disabilities of any age.

Intentionally Inclusive 4-H Club Programs. 4-H is a national organization that has made a commitment to include youth and volunteers with disabilities as program participants. This program has the mission of purposefully creating accessible environments and engaging communities to address the needs of people with disabilities. Representing this perspective are several online resources, including the following:

Websites:

Expanding Inclusive Opportunities for Youth and Volunteers, Michigan 4-H Youth Development, hosted by the Michigan State University Extension Service, *http://web1.msue.msu.edu/4h/inclusive/index.html*

4-H Programs with a Focus on Including Youth with Disabilities, Journal of Extension (April 2002), 40(2), *http://www.joe.org/joe/2002april/a4.php*

Creating Inclusive 4-H Programs for People with Disabilities, Journal of Extension (August 2004), 42(4), *http://www.joe.org/joe/2004august/a1.php*

Kids Included Together (KIT) has established connections within San Diego County to aid local youth organizations to learn why inclusion is critical for the growth of everyone in the community. KIT addresses issues related to immediate concerns of staff members as they extend programs to serve increased numbers of participants with and without disabilities in inclusive programs. While KIT does not have a STEM focus, the training it provides, which is available to a national audience, will enhance the understanding of inclusion for staff focused on informal STEM learning.

Website: *www.kitonline.org/index.htm*

NASA: Goddard Space Flight Center. The NASA Goddard Equal Opportunity Programs Office ensures complete accessibility for all programs, activities, and facilities and provides accessible materials for people with disabilities. NASA has also supported the production of tactile books by author Noreen Grice with Braille, large print, and raised line tactile drawings (titles include *Touch the Invisible Sky*, 2008; *Touch the Sun*, with Illustrations by Touch Graphics, Inc., 2005; *Touch the Stars II*, with illustrations by Irma Goldberg and Shirley Keller, 2002; and *Touch the Universe*, 2002).

The National Federation of the Blind (NFB) has an institutional commitment to promote ISE for students and adults who are blind or have low vision. NFB offers summer programs that focus on hands-on inquiry-based science, an approach that is particularly advantageous for people who are blind or low vision. Mentors who are blind, low vision, or sighted guide participants through the science activities and serve as role models. NFB also maintains the National Center for Blind Youth in Science Web Portal, a clearinghouse of information and resources regarding blind youth and STEM subjects and careers. Users may find information about how to adapt science lessons, where to find accessible math programs, and what nonvisual techniques are most effective in different STEM disciplines.
Website: *www.nfb.org/nfb*

Senior Environmental Experiences (SEE). Developed and implemented by Ramapo College of New Jersey with funding from NSF (#0407280), this STEM learning program targets seniors who experience disability as a natural part of aging. Internet videoconferencing is used "to connect seniors at community centers and extended care facilities with environmental experts at the Meadowlands Environment Center as the principal context for discussions of environmental concepts and issues." Information provided via technology and structured specifically for this population meets the cognitive goals of the program, while the physical and social aspects of the program are achieved by conducting the activities in the natural environments where seniors congregate.
Website: *www.insci.org/news/64/51/Senior-Environmental-Experiences/*