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A Publication of Informal Learning Experiences, INC

Informal Learning Review

No. 131
March/ April
2015

Inside: A look at a Fulldome Advocacy Organization

Plus: Healing through hands on science and science learning opportunities in dioramas

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Publisher information: **The Informal Learning Review** is a copyrighted publication of Informal Learning Experiences, Inc. It appears bi-monthly in February, April, June, August, October, and December. **The Informal Learning Review** is edited and published by Informal Learning Experiences, Inc., tel: 720.612.7476, fax: 720.528.7969, email: ileinc@informallearning.com, mailing address: 1776 Krameria Street, Denver, CO 80220. **The Informal Learning Review** is designed and produced in house. ISSN 1089-9367.

Subscription Information

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1 year, six issues, bimonthly, print and online: $65 in the U.S., $72 in Canada/ Mexico, $80 elsewhere. Online version ONLY, $55. Individual electronic issues can be purchased for $12 and will be delivered via email. Please contact us at ileinc@informallearning.com if you would like to purchase a single issue.

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Healing Through Hands-On Science: Exploring Museum and Hospital Collaborations

By Andrea Reynolds

Let's face it: museums, no matter the size, are filled with vibrant, creative teams who often wear many different hats. We are educators, builders, inventors, entertainers, administrators, and much more. We look to connect and improve life and education for a wide range of audiences. As such, we are always seeking to build fruitful collaborations with organizations in our communities. Ideally, these collaborations should be two-way streets that benefit both partners and help to reach the larger community. At the Ann Arbor Hands-On Museum (AAHOM), we have found a partner in C.S. Mott Children's Hospital (Mott), located just down the road from our location.

The Ann Arbor Hands-On Museum is a mid-sized, interactive science center serving over 200,000 visitors onsite and an additional 80,000 in our offsite programs annually. Visitors include members of the general public (children with their families), school groups on field trips, and those who attend special programs and events. The Museum also has an extensive outreach department which delivers programs at schools, libraries, community centers, and festivals throughout the state.

Figure 1 (Above): The Ann Arbor Hands-On Museum

Figure 2 (Top Right): C.S. Mott Children's Hospital

Figure 3 (Bottom Right): Hands-on activities for kids of all ages

Mott is a state-of-the-art hospital offering world-class care to families across southeast Michigan and beyond. For this collaboration, "Healing Through Hands-On Science" (HTHOS), AAHOM staff worked closely with the Department of Child and Family Life. These Child Life Specialists provide extensive support services to patients and their families. They have an array of programs designed to lower stress and anxiety and provide distraction, always acknowledging that the emotional needs of families are addressed and respected. What they were lacking was fun, interactive, science-based programming. In particular, there was a need for more programs for the siblings of patients, whose lives are disrupted when a brother or sister is in the hospital. Participating in a hands-on activity, even if only for ten or fifteen minutes, provides them with distraction and learning. This collaboration began just over two years ago and along the way we have learned a lot about the benefits and challenges of museum and hospital partnerships.

Hospitals and Museums are a Natural Fit for Collaborations

When AAHOM embarked on this collaboration, we didn't think much about the novelty of the partnership. However, the further we progressed in program development, the more clearly we saw how hospitals and museums are a natural fit for partnership. No matter the size of your institution, your community, or the size of your local hospital, there are several reasons why museums and hospitals are a great match for collaboration:

(1) Chances are, where there is a museum, there is a hospital nearby. There is no doubt that having a top-ranked, university-affiliated children's hospital right in our backyard was helpful in starting this collaboration. Equally important was each institution's mission of enriching the lives of children. Both AAHOM and Mott have great reputations in our city and each was seeking to expand their impact. Because we were both working toward the same goal and have very unique strengths, we never ran across the conflicts that may arise when two similar organizations collaborate.

(2) Hospitals have a built in audience. Whether they are patients, siblings, or families in waiting rooms, they spend a lot of time there. In our outreach programs at Mott, we go to waiting rooms to see kids on the way to an appointment, to the Family Center where families come to relax, and even to outpatient clinics. What's better to take your mind off of a bevy of upcoming tests and shots than making a boomerang and learning about the science of flight? We also work with the siblings of patients as part of the Family Center's Sibling Program. These children with a brother or sister in the hospital are also looking for distraction or fun.

(3) A collaboration with a hospital also provides the potential to grow a museum's audience. Mott has patients and visitors from all over Michigan and the surrounding region - people who may not have a chance to visit our museum otherwise. These patients may one day become members, volunteers, employees, or even donors to our institution because of this partnership.

(4) Healing Through Hands-On Science has also proved to be a great testing ground for new exhibits and activities. At AAHOM we strive to make our activities accessible and adaptable for all visitors. Our work with Mott patients, doctors, and therapists has given us new insight into how to do this. With their help, we have been able to improve many of our activities and tools to ensure an enriching experience for all.

(5) Collaborations with hospitals help us to connect to science experts in the community. For our museum, educating a lay audience about science is paramount and there is no shortage of experts at a world-class hospital. We connect with doctors, nurses, specialists, and therapists to bring scientific expertise that our museum staff may not have. We, in turn, can help these experts learn to disseminate scientific knowledge to the general public in an understandable, interactive way.

Healing Through Hands-On Science Starts with Outreach

There are many different avenues to explore when starting a museum-hospital partnership. Before this collaboration began, our relationship was limited to a program that provided free admission to the museum for Mott families. In November 2012, staff members from Mott and AAHOM met to explore how we could deepen our partnership and expand our reach. This meeting produced so many ideas and possibilities that a second meeting was inevitable. Input from parents of past and current patients who serve on the Family Advisory Council at Mott informed many of the programming decisions as we moved forward. A plan was put in place to develop a suite of programs and services that would occur at both facilities. We obtained seed money to pilot HTHOS with a grant from the Detroit Auto Dealers Association Charitable Foundation Fund at the Community Foundation for Southeast Michigan.

Outreach was a great entry point for us because it allowed us to start from our strength and build. HTHOS began as a monthly event in Mott's Family Center that included a small number of interactive science and math activities. Our goal was to answer questions like: who would we see, would everyone be able to participate, how much could we rely on volunteers, and how would hospital visitors know about our events? Our main goal with these outreach programs was to bring accessible activities to patients and families where they were in the hospital. We wanted to provide educational activities as a way to distract from the very real worries and concerns that patients and their families have while staying at the hospital. One challenge we encountered was determining how to adhere to the strict infection control standards in a hospital setting. Sanitizing activities between every child is not a typical procedure when we have programs at a school or library, but at a hospital, this step is a priority. We had to think more carefully about the types of activities we chose to bring and the materials they included. For example, we chose not to bring anything that involved soft cloth materials so that everything could be easily sanitized between visitors. Sometimes we had to adapt parts of activities to guard against the spread of germs. For something like bubble blowing, where visitors would normally share from a common supply of bubble solution, we made sure that each visitor had his or her own small supply of solution instead. These adaptations made our activities accessible to patients as well as their healthy family members.

Accessibility is always important when designing activities for our visitors. For HTHOS programs, we made sure to bring activities that patients in wheelchairs or with portable IV stands could participate in. We worked with occupational therapists to find adaptations for visitors who have difficulties with fine motor control, such as using turkey basters instead of eye droppers when transferring liquids. Ensuring that our programs were accessible for patients and family members was important to create a sense of normalcy and comfort in what otherwise might be a stressful situation.

Figure 4: Bringing accessible activities to patients at Mott

Another challenge we consistently ran into was marketing our events so that visitors knew we were at the hospital. Partially because we visited Mott only one or two times a month and partially because many visitors are often in and out of the hospital just for appointments, making it known to everyone that we were at Mott was difficult. The first approach we tried was creating digital signs that would scroll on a monitor in the elevators and play on the hospital's closed circuit television network. Unfortunately, these signs often promoted a program that was still a week or two away or even programs that had already happened. To solve this problem, we worked with the staff in Mott's Family Center, where most of our events took place, to move our visits to a more consistent schedule. This allowed hospital staff to inform long-term patients closer to the days of our programs. In addition, the Family Center began including our events in their monthly newsletter. Although these changes were helpful, we found the most important step in marketing ourselves more successfully was making our activities mobile. We took activities onto carts into waiting rooms and lobbies to catch families before and after appointments. We chose to seek visitors out, rather than wait for them to come to us.

Learning from Outreach and Expanding our Partnership

From our start in Outreach we were soon able to expand our partnership into two other main projects. Both of these projects are important in sustaining our collaboration and bringing awareness to it in the greater community. The first project is a shared volunteer program that allows interested volunteers to serve at both locations. When our team is at Mott, the volunteers can help us there; when Mott comes to AAHOM, volunteers facilitate activities on our floor. These shared volunteers received training at both facilities with the goal of being able to work at both venues easily.

This area of our collaboration has been the most challenging. At the start of this project, both partners tried to recruit new volunteers for HTHOS. However, we quickly found out that not only was it an administrative nightmare, but it also wasn't very successful. Our original goal was to train a cohort of 30 shared volunteers who would help at both locations. During the first year we recruited 18 volunteers, but only ever saw a handful of them serving at shared events. Whether because of scheduling conflicts or a lack of interest, the turnout was not what we had hoped for. To overcome this challenge, we decided to just recruit through the pool of incoming Mott volunteers. Mott was chosen as the starting point because they had a larger volunteer base and more established and rigorous training procedures in place.

Figure 5: Volunteers helping to facilitate activities for Healing Through Hands-On Science

Where we have really grown is streamlining the training of these volunteers. At one time all HTHOS volunteers had to complete several hours of training at each location on separate days. Not only was this asking a lot of our volunteers, it was not easy for the volunteer coordinators at each location to track who had completed all the necessary phases of training. We have since moved to simply adding a short portion of HTHOS activity facilitation training to Mott's existing volunteer orientation for those interested in our partnership. Though we are still a long way from our original goal, with these changes we are starting to turn the corner with a few dedicated volunteers that consistently come to both locations.

The second project was to host several "Teddy Bear Clinic" days at AAHOM throughout the year. The Teddy Bear Clinic is a program designed by the Child Life Specialists at Mott to teach children how their bodies work and about simple medical procedures in order to lower anxiety and fear. The Teddy Bear Clinic includes a mock operating room where children dress up like doctors and take their stuffed "patients" through medical procedures including basic height/weight/heart rate measurements, x-rays, and MRIs. Visitors learn how casts work while putting "finger casts" on themselves and even participate in a research study that investigates how much medical vocabulary children are familiar with. The Teddy Bear Clinic is staffed with Mott Child Life Specialists, operating room staff, and their own children. By bringing this program to AAHOM, we are able to teach health science to a large, diverse, and healthy audience in a nonthreatening environment. The three Teddy Bear Clinic days have drawn over 2,500 visitors at AAHOM, bringing much needed community awareness to this partnership.

The Benefits of Museum and Hospital Partnerships

Many studies have been done about the effect therapeutic play can have on anxiety and fear in young patients. According to research done by Li and Lopez that studied the effectiveness of therapeutic play in children preparing for surgery, "Children who received therapeutic play intervention reported lower state anxiety scores in the pre- and postoperative periods than children who received information intervention" (Li and Lopez, 2008). Therapeutic play allows patients to learn about procedures in a nonthreatening way and thus gain a greater sense of control in the situation. This sense of control lowers feelings of fear and anxiety for both patients and their families (Li and Lopez, 2008). The Child Life Specialists at Mott put these ideas into practice every day. Illness or hospitalization affects the family of patients as well. Our partnership brings programs that create normalcy, comfort, and distraction for families during their healthcare journey. We have found this collaboration is not only beneficial to patients and their families, but also to museum and hospital staff.

Mott and AAHOM are very different places. We came into HTHOS with different resources and strengths and have been fortunate to form a deeper connection that builds on these strengths. This collaboration has helped hospital staff by giving them a large, diverse audience to teach health science. It has helped them to learn to communicate with an audience that does not have the same experience or background knowledge as their peers and colleagues. This experience makes them better caretakers and communicators. In addition, nurses, doctors, and other support staff who work with hospitalized children everyday also need a break from that stress. They found the Museum environ-

Figure 6 (Left): Taking care of "patients" at The Teddy Bear Clinic
Figure 7 (Right): Mott staff volunteer at the Teddy Bear Clinic

ment, where they could interact with healthy children, to be nurturing for them as well. HTHOS has made AAHOM staff take a second look at our activities and exhibits, making them accessible to everyone and considering how we can better cater to this portion of our audience. We have also learned a great deal about how to communicate with patients in a hospital setting and the importance of play in a stressful situation.

Rethinking our Idea of Success

At many museums, the success of any program is measured by the number of people who attend. Because it is easier to report and understand quantitative measures of success, this is a hard figure to ignore. At the beginning of HTHOS, we often returned from programs disappointed because our staff didn't interact with a large number of participants. Over the initial grant period we reached over 400 people at Mott during 24 weekday and 4 weekend programs. During this time there were approximately 9,000 inpatient admissions at Mott. STATCOM, a student group at the University of Michigan, that provides pro bono statistical consultation to local government and nonprofit organizations, helped us design outcome-based evaluation tools. The challenge we faced was getting a sample size large enough to establish any significant findings. Very quickly, we realized that this is a program centered not on the number of people we reached, but instead on the quality of these interactions. We had to rethink our definition of a successful program. This fact became an important issue to explain to donors when we were seeking additional funding after the initial grant period ended.

These are some examples of feedback we have received:

Great program! My son loves science and this really helped keep his mind off the pain. He's really excited and wants to come visit your museum.

Mott Hospital seems to have a lot of activities for the children that help them have fun while in the hospital.

Looking forward, we have been able to secure three additional years of funding for Healing Through Hands-On Science from The Carls Foundation and are excited to build on the programs we have started. This year we are hoping to provide distance learning lessons in the hospital classroom and are in the process of designing an exhibit for the Pediatric Infusion Clinic at Mott.

Finding an advocate at your local hospital is crucial to making a partnership like this work. Many collaborations can stall without the right people on the other side ensuring that logistical details are figured out and both parties are on the same page. We owe much of the success of Healing Through Hands-On Science to our partners in the Department of Child and Family Life at Mott. As much as we have shouted from the roof tops our excitement over this collaboration, they have been our partner in making HTHOS programs known to other hospital departments, board members, and executive management. The success of these programs, which provide no tangible financial benefit to either organization, can only be sustained with support from every level of the collaboration.

Other Possibilities in Museum-Hospital Partnerships

At the 2014 Association of Science and Technology Centers Conference we were invited to co-present a session, "Building Community Partnerships: Hospitals and Museums Realize Shared Healing Connections." The other presenters were COSI in Columbus, OH, who partner with Mt. Carmel Hospital to show students live surgeries via interactive video conferencing, and TELUS Spark in Calgary, Canada who have prototyped museum exhibits at a local hospital. Both of these programs have served as inspiration and encouragement as we progress in our own collaboration, and are great examples of the opportunities for a museum - hospital partnership.

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IMERSA: A Fulldome/Immersive Advocacy Organization

By Carolyn Collins Petersen, Dan Neafus, Ryan Wyatt, Michael Daut

Introducing IMERSA
Immersive Media Entertainment, Research, Science & Arts (IMERSA) is an advocacy group for fulldome and immersive digital media, formed to help producers, artists, and hardware and software developers communicate, share, and promote their work, and create standards for production and presentation. This community embraces a wide spectrum of immersive experience—from fulldome planetarium shows and experimental performance art to personal virtual reality products such as the Oculus Rift.

IMERSA raises the profile of immersive digital video and represents its creators at a number of events, such as the Société des Artes Technologiques IX Symposium in Montréal, the Jena FullDome Festival in Germany, and International Planetarium Society conferences. The group fosters professional development, encourages fulldome standards, aggregates business metrics, and prepares "white paper" reports on best practices and other issues.

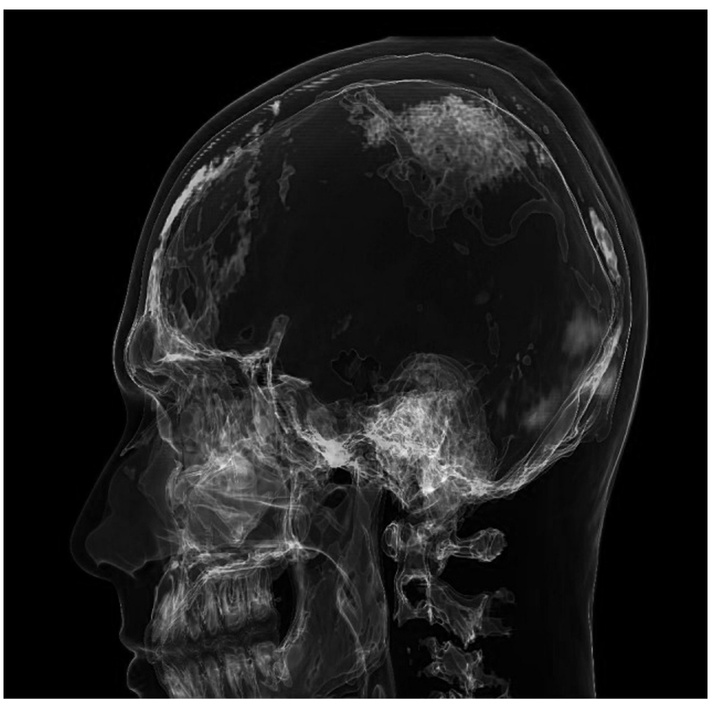

Figure 1: A fulldome 3D model of the human brain from Neurodome*: an example of science visualization that moves beyond the traditional "stars and planets" shown in domed theaters. Photo courtesy of Neurodome Project.*

The World of Immersive Media: From Planetarium to Fulldome
The world of immersive media that IMERSA serves is rapidly advancing in theaters around the world. The largest subset is in planetariums, which have been going digital themselves—from "classic" theaters (those with opto-mechanical star projectors and slide projection systems) to fulldome theaters with digital video projection and audio systems. Another group of theaters self-classifies as "giant screen dome" theaters (with film-based projection systems such as IMAX™). As these theaters convert to digital projection, opportunities for crossover between the two communities expand. IMERSA has remained at the forefront of "convergence" discussions between the two populations.

The growth of fulldome systems has occurred rapidly. In 2007, there were 316 fulldome-equipped planetarium theaters; in 2015, there are at least 1,316 fulldome theaters, although anecdotally many more are known, but remain officially unreported.

This rapid growth stems from fast advances in digital technologies that fuel fulldome—from video projection systems and computerized databases to visualizations and pre-rendered shows. As fulldome systems become more accessible and affordable, even schools and small science centers can install high-quality systems.

In recent years, real-time scientific visualizations have added new dimensions to audience experiences. Digital technology makes it possible to present live shows (much like being immersed in a giant video game) that navigate scientifically-accurate models extending from human neurons out to the reaches of the known universe. Digital systems also allow both interactive and movie productions to be integrated into a single program—and to be exchanged between locations.

What content do these theaters run? Most fulldome theaters are associated with educational institutions. Thus, they focus on educational content, often aligned with science education standards, typically featuring space science and astronomy (Petersen, 2014). Recent productions emphasizing topics such as geology and biology are adding diversity to the fulldome repertoire, utilizing sophisticated visualizations and spherical panoramas. Live performance

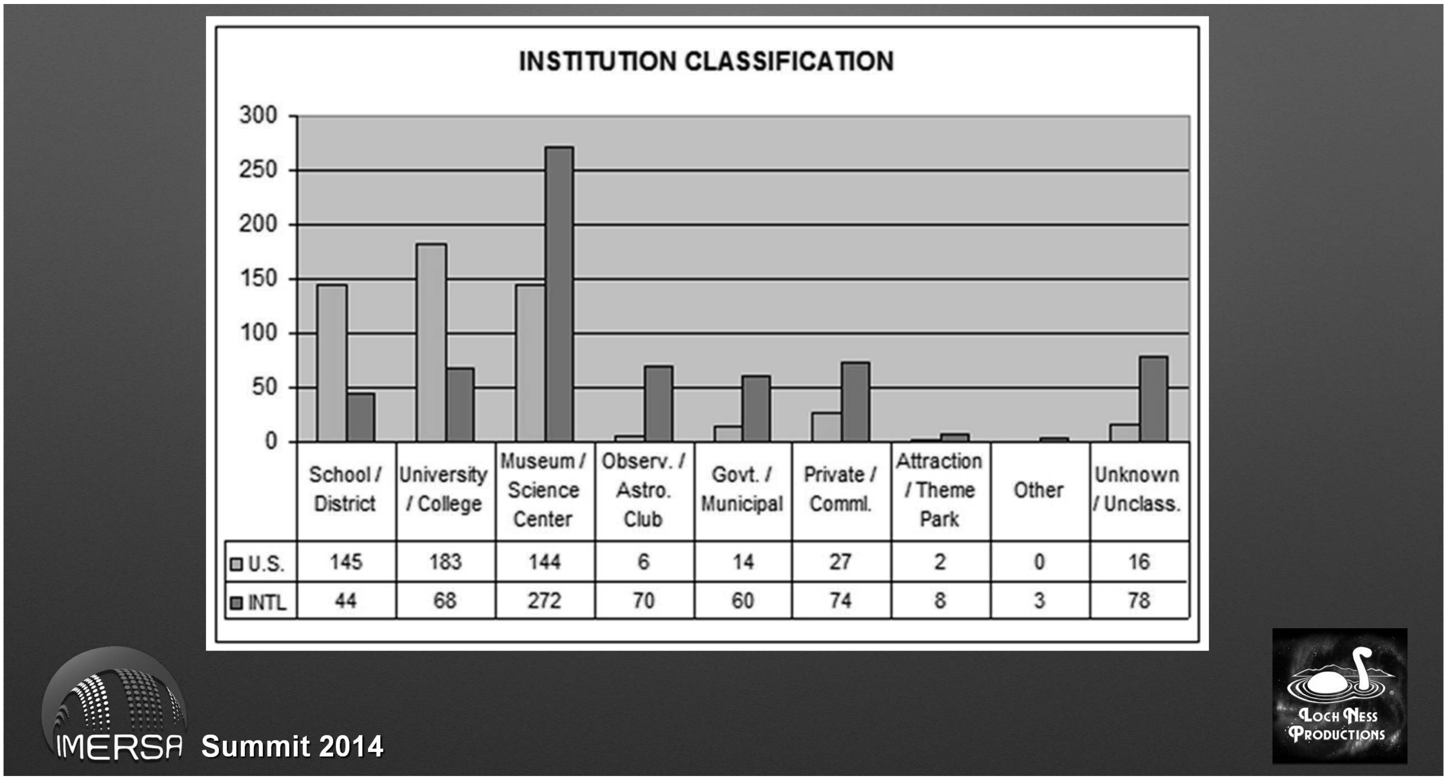

Figure 2: The Institutional Classification of Fulldome Systems in 2014, from "State of the Dome" by Mark C. Petersen.

art, complex computer-animated entertainment pieces, and giant screen film conversions are also finding their way onto the dome. In addition, non-dome applications (Oculus Rift and others) are becoming part of the immersive conversation that IMERSA is brokering.

IMERSA History

IMERSA's roots are deeply embedded in the rise of fulldome and the search for common standards in production and projection. Early standards efforts were held at the 2004 International Planetarium Society meeting in Valencia, Spain, a seminal event for the formation of IMERSA as a stand-alone organization (IMERSA, 2004).

IMERSA was incorporated in 2008 after a launch at the IPS conference in Chicago, IL. Meetings followed at various conferences including sessions at SIGGRAPH and ASTC and joint symposia with the Jackson Hole Wildlife Film Festival in 2010 and 2012. The annual IMERSA Summits have seen tremendous attendance growth, from 78 participants in 2012 to 225 in 2015. Each of these events has provided further explorations of the fulldome medium and widened the "footprint" of immersive media to other producer communities.

IMERSA Summits and Their Outcomes

The Summits are IMERSA's primary outreach mechanism. They are currently hosted at the Denver Museum of Nature and Science, and attract a global audience of museum and planetarium professionals, producers, equipment manufacturers, animators, artists, and actors.

The most recent Summit, held February 25 to March 1, 2015, featured live events such as CEREMONY, a concert presentation by artist James Hood, Bella Gaia performed by Kenji Williams, and selections from the play The Kepler Story by Nina Wise. Professional sessions included an IPS-sponsored workshop on visualizing big data in the dome, and panel discussions on real-time content, immersive audio, theater business models, content selection, alternative content, and education research in fulldome—all topics designed to give attendees "take-aways" to use in their own work.

Fulldome screenings featured several full-length shows and a "works in progress" session. These were shown at Gates Planetarium in Denver and Fiske Planetarium in Boulder. The 2015 Summit also had its first-ever "Pro.Show" networking event, featuring producers, equipment vendors, and others in a dedicated three-hour networking session. The last day of the meeting featured topical meet-ups focused on live performance, projection and production standards, and VR production.

The Future of IMERSA

IMERSA continues to be a hub of conversation among fulldome and immersive professionals. As technologies and programming advance, IMERSA will nurture many forms of digital immersion, from headsets to spherical screens to inverted hemispheres. IMERSA members have seen domed

Figure 3 (Above): IMERSA attendees learned about the latest technologies, animations, and productions at the "Pro.Show" Networking Event, designed to facilitate discussions among technology vendors, producers, animators, and performing artists. Photo courtesy of IMERSA.

Figure 4 (Below): Producers are finding such technologies as Oculus Rift a useful tool in production and visualization of fulldome and immersive content. Photo courtesy of IMERSA.

theaters grow to embrace not just flights through the starry universe that is the dome theater's proud heritage, but also to explore programming that highlights other fields of scientific research. IMERSA will continue to foster the growing interest in digital fulldome cinema, immersive entertainment, performance art, animated worlds, and other innovative content, through its Summits and other activities.

Further information and videos about the events and topics addressed in this article can be found at www.imersa.org.

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Acknowledgements

The authors thank Ed Lantz and Mark C. Petersen for their insights into fulldome and its influence.

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Bringing the Mission to the Community: State Museum Opens a Satellite in an Underserved Rural Region

By Emlyn Koster and LuAnne Pendergraft

Introduction

As museums endeavor to diversify and grow their audiences to be more representative of their communities, students and families defined by socioeconomic criteria and variously referred to as at-risk, disadvantaged or underserved are a high priority. With proactive measures that include reduced or free admissions and special access programs, institutions gradually strengthen their meaning and case for support, and sometimes so in transformative ways.

An example was the systemic state-wide partnership developed at Liberty Science Center to provide New Jersey's at-risk schools and communities with onsite, offsite and online science learning and teaching programs at no charge to them (Koster and Baumann, 2005; Koster, 2007). Begun in 1997 and continued through the 2005-07 temporary closure of the Center during its major expansion and renewal project, this program was supported by both major political parties in New Jersey with annual supplementary appropriations reaching $6.6 million. An independent program audit in 2005 by WestEd of Washington, DC, concluded that Liberty Science Center was providing "a far-reaching return on New Jersey's investment". The Center's community-driven philosophy next became evident in its immediate and multifaceted involvement in the region's arduous recovery from the terrorist attacks on the World Trade Center in New York City across the Hudson River, one mile away, on September 11, 2001 (Gaffney, Dunne-Maxim and Cernak, 2002).

North Carolina Museum of Natural Sciences

Founded in 1879 by the North Carolina Legislature, the North Carolina State Museum of Natural History in Raleigh, the State capital, was initially guided by wildlife biologists and taxidermists. Part of the Department of Agriculture, its growing focus on nature, natural history and the economic context of natural resources became enriched by education and volunteer programs. During 1990-2012, and with the institution by then renamed the North Carolina Museum of Natural Sciences and switched to the Department of Environment and Natural Resources, the Museum embarked on a two-phase expansion to focus on the questions of 'what do we know?' with a North Carolina focus and then 'how do we know?' with a global research focus.

In 2013, strategies to reap the maximum dividends from the cumulative volume of public and private sector investments became the institution's focus. Propelled by an updated mission to illuminate the interdependence of nature and humanity, the Museum is both a major contributor to knowledge about the natural world in partnership with universities and a major educational resource to schools and the public. Outreach to the State's underserved rural communities and to students with disabilities as well as the integration of the natural sciences with the humanities, social sciences and the workforce became rising areas of attention.

Extending Outreach

The NC Museum of Natural Sciences is the largest institution of its type in the southeast USA and the State's most visited museum with annual attendance approximately 10% of the State's population of 9.94 million. Its busiest days are those with featured experiences, each involving many community partners, with visitation twice to ten times the daily average. Yet despite its large profile and free general admission, the Museum needs extraordinary measures to reach underrepresented audiences. A key component of such strategies, learned over time from the above-mentioned Liberty Science Center experience, is that traditionally underserved communities, whose schools and families may be without a museum-going tradition, need a clear invitation plus easier access to resources. The tipping point for the NC Museum of Natural Sciences came about in November 2013.

What had been an empty and renovated bank branch building in Whiteville, 115 miles south of Raleigh, was assigned by the State Legislature to the NC Museum of Natural Sciences in 2000 with the intent for it to become a satellite Museum of Forestry to elucidate North Carolina's $19 billion wood products industry. However, this purpose was never realized. Small temporary exhibitions occupying part of its ground floor drew low attendance; plus, Whiteville's population of 5,500 and its location away from interstate highways thwarted the initial vision.

The NC Department of Commerce annually ranks the State's 100 counties based on economic well-being. The 40 poorest counties are designated as Tier 1 (one of which is Columbus County, where Whiteville is located, which currently ranks 11th), the next 40 as Tier 2, and the 20 least distressed as Tier 3 (the most affluent of which is Wake Country which contains the State's Research Triangle and Raleigh). This system is incorporated into various state programs to encourage economic activity in the most challenged areas.

In November 2013, a status review by the nonprofit Friends of the Museum of Forestry with senior staff from the NC Museum of Natural Sciences and the State Government unanimously decided to pursue a new vision for the underutilized building. Replicating proven types of indoor laboratory and outdoor nature playspace environments at the headquarters Museum and its nearby Prairie Ridge Ecostation, this meeting excitedly imagined a nature learning center for children in school and family settings for an underserved rural region as a superior use of available inside and outside spaces. Over the ensuing months, this scenario gained wide support and became a reaffirmed integral part of the NC Museum of Natural Sciences in the State's 2014-15 Budget with a proviso that the local Friends organization raise $100,000 of extra funds during the first fiscal year as confirmation of the community's interest.

During 2014 as the Museum looked forward from its consuming capital phase, the whole organization engaged in waves of debate to arrive at definitive statements of the Museum's history, mission, core values, tagline, and form-follows-function goals (a refined strategy to achieve a 2020 vision of an even more compelling state of the Museum's community value to environmental stewardship and educational innovation is the next step). The task force who worked on core values—comprised of twenty nominated members spanning 2-30 years of service across the organizational structure—concluded first that the Museum is propelled by distinctive, service-driven ways of thinking, acting and reacting. The task force then unanimously arrived at a three-layer integrated suite of the Museum's values: foundation (integrity, professionalism and commitment), approach (inclusion, innovation and collaboration), and outcomes (engagement, impact and sustainability). When task force members presented their work at a Museum professional development day a few weeks before hosting the ASTC conference on October 18-21, both they and the audience were full of emotion. The teamwork to design and open the NC Museum of Natural Sciences at Whiteville was poised to become a poignant display of the institution's core values.

Between November 2014—right after the NC Museum of Natural Sciences hosted the ASTC annual conference—and January 2015, a cross-functional task force designed the new experience in Whiteville. Chaired by the second author with a mandate to limit the repurposing expenses to the $100,000 raised by the Friends, its experienced members represented administration, facilities, exhibitions, digital media, onsite/offsite/outdoor education, and marketing and communications, each frequently traveling back and forth with overnight and multiday trips. The four Whiteville-based staff members embraced the programmatic shift, and the board of their local Friends organization spurred the transformation with enthusiasm and fund-raising progress. That a success story was in the making was palpable: the Museum's core values were in a turbocharged state of application.

Figure 1: A former bank, the North Carolina Museum of Natural Sciences at Whiteville.

Opening events in Whiteville were scheduled for February 27-28, 2015. A Friday evening by-invitation reception was attended by the entire range of local and state officials and community leaders along with the satellite's local board, staff and volunteers. A video greeting of congratulations from Governor Pat McCrory of North Carolina was shown. The gallery space swelled with 180 guests, a total that exceeded what was already an impressive response to invitations, who then engaged with the range of new programs and activities which were unveiled. 10 am on Saturday was the grand public opening ceremony, an event surrounded by much local buzz. Local and statewide elected officials, school superintendents, and community leaders along with families from across the region, gathered to celebrate this event and engage with the range of hands-on science and nature-based learning opportunities. Science Fair winners from local elementary schools were selected to cut the ribbon—a natural floral vine —while music from the East Columbus High School Jazz Band set a festive tone. By the end of the day, over 1,100 visitors had explored the Museum—20 percent of the Whiteville population.

Opening speakers included the State Senator and House Member for Whiteville, Mayor of Whiteville, President of the Columbus Chamber of Commerce and Tourism, Superintendents of Columbus County Schools and Whiteville City Schools, the Director of the NC Museum of Natural Sciences, and the President of the Whiteville Play Group. Elise Belmont of the Play Group delivered remarks that poignantly summed up the significance of the occasion:

"In a county where 41% of children live below the poverty line and many families must choose between gas money and groceries, having the Museum of Natural Sciences in our county seat is life changing for many of our young children and their families …We are a relatively small community in terms of numbers, but we are great in our potential. Just look in the eyes of every, single child here today and you will see the promises of tomorrow. Some may wonder if the expense of a new museum in such a small town is worth the price, but I can say with much confidence, there is no greater place to invest in than a small town. Our tiny community and others like us give children the safety of many helping hands, the accountability of small numbers, the support of strong families, and the values of good Americans. Combine this with the NC Museum of Natural Sciences at Whiteville, contributions of the latest technology coming from the greatest minds, and our children have all the resources and support they need to make huge changes come from this small part of the world ... As our children are given the opportunity to express themselves and safely engage in their innate need for physical activity and mental stimulation, their self-esteem rises as they discover all they are capable of. Today's tummy-crawlers, happily exploring in their own safe environment, are tomorrow's microbiologists. Today's toddlers, banging pots and climbing trees, are tomorrow's engineers".

On March 2 The News Reporter of Whiteville ran an editorial titled "An amazing start for a new kind of museum":

Figure 2: In front of public officials, local science fair winners cut the ribbon at the opening ceremony.

Figure 3: Elise Belmont, President of the Whiteville Play Group, at the opening day ceremonies.

"The numbers tell the story, one of strong interest and support of the North Carolina Museum of Natural Sciences at Whiteville. However, the real story could be seen in the faces of the intergenerational, the multi-ethnic and the cross socio-economic visitors to the museum. Parents and children were looking through microscopes together. A foster grandmother was taking pictures of her foster grandchildren interacting in the museum's Discovery Forest. Adult educators, teenagers, and moms and dads with young children were all finding joy in micropipetting 'painting', handling beaver skeletons and bear fur and even observing insect and animal scat. In other words, the opening weekend was a snapshot of the amazing potential the museum has in providing our rural, underserved area with high-quality educational activities … In fact, supporters of the museum believe the Whiteville facility will be a prototype for the rest of the state and perhaps the nation for bringing science and nature learning directly to the people. The grand opening weekend is only the beginning of the story. Much depth and width of plot is under development. This story can be an epic prototype – one that blesses the community and the state for years to come … Organizers were overwhelmed by the show of support by the public at Saturday's grand opening of the NC Museum of Natural Sciences at Whiteville. The good news is that the folks in Raleigh know how to run a world-class museum, and now they're bringing their show on the road where people can learn and enjoy close to home."

Then on March 3, The News & Observer in Raleigh ran an editorial titled "A world opens":

"Columbus County, two hours due south of Raleigh, in a rural underemployed region of North Carolina might seem like an unlikely place for a satellite of the state Museum of Natural Sciences. But that is exactly why it has become home to its own museum branch. The wise strategy of the state museum is to reach out to rural areas and in particular to the children of those regions to give them a taste of science, a chance to share in the wondrous world of the spectacular museum in downtown Raleigh … The ambition of Emlyn Koster, the museum's director, is for other communities in the state to find space for their own branches…"That," he said, "would be the ace in the pack." Yes, that's it exactly, as that young child who lives without the experience of having a museum within reach might feel a spark that would lead him or her to the goal of being a scientist or to a grander world of learning. About 75 percent of public schoolchildren in Columbus County are poor enough to receive free or reduced priced school lunches. Underemployment is too high, and the region is isolated. But now it is home to part of the North Carolina's much-praised Museum of Natural Sciences. That is a victory."

On February 28 the Whiteville opening became a Google alert of museum field news; within a week it had become an Associated Press story with pick-up across the USA. Since the opening weekend local interest in the Museum has remained high. Satellite staff have established a full menu of engaging science programming, targeting a wide range of audiences from story times and afterschool programs for preschool and school age audiences, to science cinema programs and nature treks, to evening teen science cafes, and for families and the community in general. Additionally, school groups from across the region—including from neighboring South Carolina—are flocking to the new space, completely filling every available school program.

Looking Ahead

This North Carolina project has positioned itself as a proof of concept that major museums can create microcosms of themselves in communities two or more hours away in driving time and with limited discretionary travel resources. Judged by the resounding success of the opening ceremonies in terms of the content of speeches by influential figures, local fundraising that exceeds the first year $100,000 goal, local and nationwide news coverage, attendance numbers, and advance reservations, this project is deemed a resounding success to date. It is also one with very strong potential of sustainable success as evaluated over time, for example, by the career ambitions and achievements of local students and the perceptions of local officials, social service agencies and families that the Museum has elevated the quality of life in an enduring way.

Already, the Museum's new satellite in Whiteville is viewed as a positive contributor to the region's economy. Gary Lanier, Director of the Columbus County Economic De-

Figure 4 (Left): Opening day visitors in the natural world investigate lab section of the Museum's new branch.

Figure 5 (Top Right): Opening day visitors in the natural world investigate lab section of the Museum's new branch.

Figure 6 (Bottom Right): Families in the naturalist center section of the Museum's new branch.

velopment Council, has described the benefit with this statement:

"Having a branch of the North Carolina Museum of Natural Sciences here in Whiteville provides children throughout southeastern North Carolina with unprecedented learning opportunities. As an economic developer, I am especially excited with the transition taking place here. In today's high tech world, having a workforce that is well-schooled in science, nature, mathematics, ecology, and technology is critical to economic development. We will now be able to provide students living in our region with access to some of the same types of learning experiences that are available to their peers in Raleigh and other metropolitan areas of the State. That can only strengthen the skills and abilities of the children that will be the core of our workforce here in southeastern North Carolina in just a few short years." (http://naturalsciences.org/about-us/news/north-carolina-museum-natural-sciences-open-whiteville-branch-natural-world-learning)

There is a broader result which may well be the most powerful one over time. Wilson (1984) introduced the term biophilia to refer to an innate positive bond that humans have with other living systems in nature. On a related note, White (2004) stated:

"Not only does the loss of children's outdoor play and contact with the natural world negatively impact the growth and development of the whole child and their acquisition of knowledge, it also sets the stage for a continuing loss of the natural environment. The alternative to future generations who value nature is the continued exploitation and destruction of nature. Research is clearly substantiating that an affinity to and love of nature, along with a positive environmental ethic, grow out of children's regular contact with and play in the natural world."

Through its provision of indoor and outdoor learning environments about the natural world in Whiteville, the NC Museum of Natural Sciences is spearheading an area of progress in line with the above-referenced philosophy. Mindful of the additional following aspiration, we encourage other institutions to consider similar initiatives in their regions. Gijssen (2010) imagined:

"The museum becomes critical to the long-range health of a place: central to think-tanks, planning initiatives and community transformations … It is an institution others actively seek for guidance and expertise, harvesting from its knowledge, communication methodologies, community connections, and relationships … In such an ecosystem, the museum's role does not have to be explained or rationalized: [others] embed it in their governance, research and educational programs."

To a field yearning for greater external relevance (Anderson, 2012), Gijssen provides us with a laudable goal.

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Acknowledgments

On behalf of the Whiteville community and its surrounding region, our warm gratitude goes to advisory commission members, board members, public officials, staff and other volunteers of the North Carolina Museum of Natural Sciences in Raleigh and Whiteville who have helped to nurture a bold idea into a reality.

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Exploring Connections Between Physical and Mathematical Knowledge in Science Museums

By Tracey Wright and Alana Parkes

The designers of the *Math Moves!* exhibits have worked hard to support visitors' qualitative, kinesthetic understanding of the topic of ratio and proportion. How did we, as designers of math exhibits in science museums, attempt to make connections for visitors between embodied understanding of mathematics and more abstract knowledge? How have they come to view what counts as mathematics?

Embodied understanding, or kinesthetic learning, is one of eight types of learning styles defined in Howard Gardner's theory of Multiple Intelligences (Gardner, 2011). Bodily kinesthetic learning styles, or intelligence, refer to a person's ability to process information through hand and body movement, control, and expression. Bodily kinesthetic intelligence entails the potential of using one's whole body or parts of the body to solve problems. It is the ability to use cognitive understanding to coordinate bodily movements, for example, learning to catch a ball. As Rafael Nunez (1999) puts it, "Cognition itself is embodied, and the bodily-grounded nature of cognition provides a foundation for social situatedness, entails a reconceptualization of cognition and mathematics itself, and has important consequences for mathematics education."[1] According to Shelly Weisburg (2006) there is an inclusive role for such a learning style in both formal and informal environments, "Movement as nonverbal communication probes beyond socioeconomic and educational boundaries allowing those who might not be verbal or auditory learners to be integrated into the learning process." Kinesthetic learning invites math/science learners into a new conceptual space, which may provide access to those who might not typically be engaged.

What is Math Core? What is *Math Moves*?

Math Core is an NSF-funded collaboration (DRL-0840320) of four museums working to develop, install, and study a suite of exhibits about ratio and proportion for children ages 6–12 and their families. According to the National Math Advisory Panel Report (2008), facility with fractions, ratios, and proportion is one of three critical foundations for students' success in algebra. Over two years, four museums (Explora, Albuquerque, NM; Museum of Science, Boston, MA; Museum of Life and Science, Durham, NC; and the Science Museum of Minnesota, Saint Paul, MN) articulated a set of principles to guide exhibit development[2] and developed and tested 16 exhibit components. Each of the exhibits includes an opportunity to explore the concepts "twice" and "half" in a variety of contexts, including area, volume, weight, time, and rate. After considerable evaluation and discussion, we selected a core set of seven components (including Partner Motion, which we discuss below) for installation in each of the museums. Each museum added some of the original 16 exhibits, resulting in four unique exhibitions called *Math Moves*. Installation took place in January 2012.

Partner Motion

In this exhibit, two visitors use two motion detectors to explore their rate of travel along a rainbow-colored path. Walking back and forth, slowly and quickly, visitors create distance vs. time graphs. They can match pre-made graphs or create their own motions and graph shapes. The graph lines on screen (one black and one white) display in real-time their position over time, giving them direct proportional slopes. This provides a way for them to think about and feel how their rates compare to each other as well as to their individual motions. It also allows them to create interesting shapes together. This is not as easy as it might seem, because it requires that they move in particular ways in relation to the graph as well as to each other.

In Math Core, one question we were particularly interested in was, "How do you design and study exhibits from the perspective of embodied cognition?" This article explores the connections visitors made between embodied understanding of mathematics and more formal knowledge and the design strategies we employed to support mathematical understanding in the Partner Motion exhibit.

A qualitative understanding of rate is an important way to connect to the numbers. In an informal setting, we wanted to develop people's intuitive, informal notions of ratio. For example, when one middle school math teacher was asked about what was difficult for students in terms of fractions, ratio, and proportion, she immediately said, "Context; kids have no context for thinking about these ideas."[3] By exploring rate and ratio in a variety of physical contexts, we are building a conceptual understanding of rate.

We also hoped to give people a physical memory that involves playing with ratio and proportion so that later when they encounter more formal notions, they could make a connection to this experience. As Annie Murphy Paul (2014) states, "One reason involving the body improves learning is that bodily movements provide the memory with additional cues with which to represent and retrieve the knowledge learned. Taking action in response to information, in addition to simply seeing or hearing it, creates a richer memory trace and supplies alternative avenues for recalling the memory later on."

Preparing to Develop a Bodily-based Exhibit

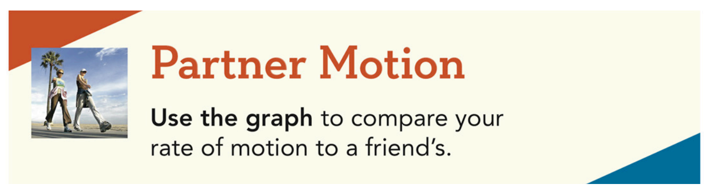
In designing Partner Motion, we first developed our own understanding of rate of change. We read and discussed a lot of literature on ratio and proportion as well as on embodied cognition (Jones, Taylor & Broadwell, 2009; Lamon, 2007; Nemirovsky & Ferrara, 2009: Singer & Goldin-Meadow, 2004; Carraher, 1996). We consulted with a Tufts student (Jason Kahn) who was doing his dissertation on Science Education with a focus on Physical Motion (2010) on exhibit design features. Andee Rubin, Senior Scientist at TERC, shared her experience with change over time representations on the CamMotion project and in the Design Zone exhibit (http://www.designzoneexhibit.org). We led a half-day workshop with a Boston-based dance teacher (Andy Taylor-Blenis) and six experts in the field of body motion and design from formal and informal settings.

We drew on previous experience developing math exhibits, including findings from the *Handling Calculus* exhibit (Gyllenhaal, 2006) that showed that some visitors get anxious if they think they are about to do math, because of previous bad experiences. This is contrasted with our experience at the October 2011 ASTC session (Doing Math with your Body), where we found that people who didn't normally like mathematics felt comfortable and interested in the *Math Moves* exhibition in general. However, they and others wondered if what they were doing was considered "real" math. They wanted us to draw more explicit connection to the more formal mathematics that is valued in schools.

This raises questions for designers of math exhibits regarding how to support the development of mathematical understanding. For example, how important is it for a visitor to know what math topic they are working on? If a visitor does the activity, but is not articulating how they did it, does that "count" in terms of showing evidence of mathematical understanding?

Developing Partner Motion

Historically, in formal education environments, motion detectors permit students to explore the modeling of their own body movement through space by means of real-time graphical displays (Arzarello, Pezzi, & Robutti, 2007; Nemirovsky, Tierney, & Wright, 1998; Robutti, 2006). The area of formal mathematics that Partner Motion addresses is rate of change. Rate of change is a rate that describes how one quantity changes in relation to another quantity, in this case, distance over time. The slope (incline) of the graph line describes its steepness. The greater the slope, the steeper the line and the faster one has travelled. A horizontal line indicates that motion has stopped. This is related to Math Core's goal of focusing on ratios, since a ratio is a comparison between two numbers, or a relationship between two quantities.



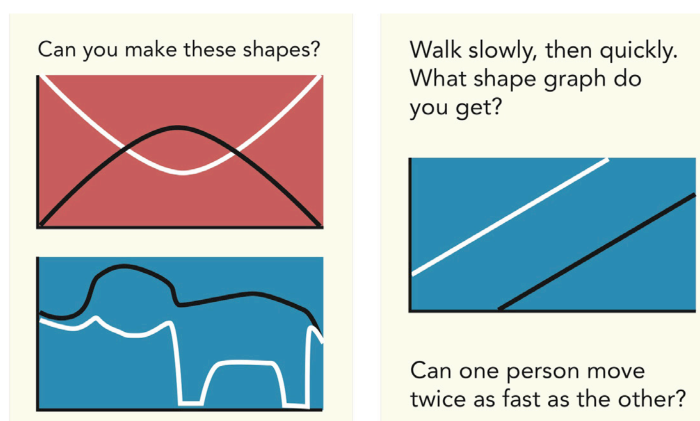


Figure 1 (Top Right): The title graphic for Partner Motion. Photograph courtesy of the Science Museum of Minnesota. Figure 2 (Left): A prototype version of Partner Motion installed at the Science Museum of Minnesota. Photograph courtesy of the Science Museum of Minnesota. Figure 3 (Bottom Right) : Print graphics pose challenges for visitors. Prompts on the screen pose challenge questions such as: Can you make mountains? Can you make an elephant? What other animals can you make? Photograph courtesy of the Science Museum of Minnesota.

Testing with Visitors

At the Museum of Science in Boston, we tested different versions of Partner Motion with about 90 groups of visitors over the course of a year. This allowed us to try out different features including the impact of a second motion detector, rainbow tiles, and even footprints. Our goal was to provide a meaningful physical experience that could lead to a mathematical understanding of rate and to foster conversation among visitors.

From One Motion Detector to Two

Partner Motion was developed at the Museum of Science in Boston, MA. It was inspired by exhibits at the Science Museum of Minnesota and at the Museum of Science in Boston, at which visitors could engage with a single motion detector which measures a visitor's distance from a sensor in real-time and graphs their rate of motion on a computer screen. With a single detector, visitors could ask questions like "What does it feel like to move twice as fast?"

Adding a second motion detector created a more playful experience. One visitor said, "It'd be fun to try to create the pictures, to work together to try to do something" (Wright and Parkes, 2010-2011). It also allowed visitors to explore additional questions comparing their rates, such as, "Can I move twice as fast as you? What would it feel like? How would my motion look compared to yours? What would the graph look like?"

A second motion detector also increased the amount of mathematical conversation. Conversation helped visitors connect their physically embodied experiences to mathematical learning. A mother noted that, "Your [graph line] went up and mine went down. You went backwards and I went forwards." Visitors collaborated more: talking to each other about how they would move, planning their motions, and afterwards, engaging with each other about how successful they were. Talking about the graphs they made together was an important way to develop and solidify understanding of rate. A father making a graph declared, "Oh, I get it. I'm going to start on this and stay on one color each second. I'll back up diagonally? No, straight." Parents on the sidelines often participated by asking questions that were not posed on the surrounding text. "Can you move slow like a turtle?" "How can you make opposite lines?" "Can you make parallel lines that aren't horizontal?" Other conversation from the sidelines offered suggestions of how to move in order to better create the desired pattern. With his wife trying to double their daughter's speed, one dad commented, "Now you're parallel again. One of you slow down."

Ricardo Nemirovsky, co-Project Investigator of Math Core, says, "Fusion of physical action and graphical shapes is a major resource to engage students in conversations around the production and the interpretation of graphs" (Nemirovsky et al., 1998). Partner Motion provides two visitors with an opportunity to see how each of their individual rates of motion create two graphs on one screen. It potentially enables them to have a deeper experience of rate, by comparing their different speeds and thereby experiencing a ratio of rates.

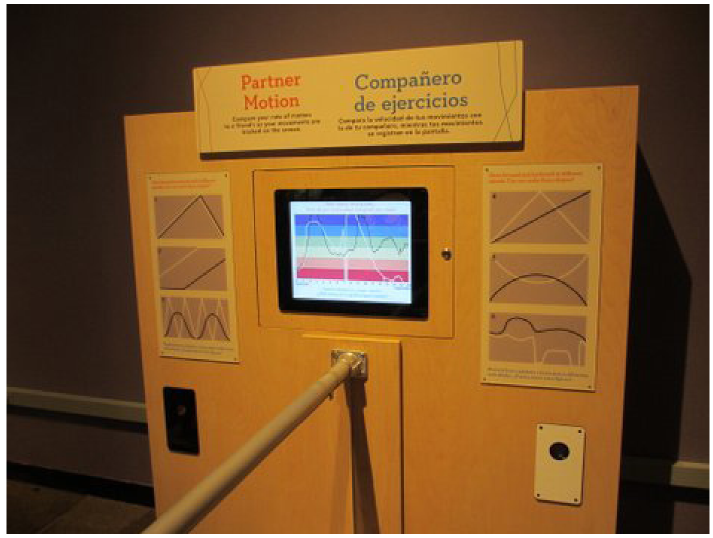


Figure 4 (Above): A graph created by two visitors. Photograph courtesy of the Science Museum of Minnesota.
Figure 5 (Below): A pair of visitors using Partner Motion. Photograph by Rich Fleischman.

Adding a Rainbow and Footprints

Early versions of the component used numbers on the floor that corresponded to numbers on screen indicating distance. Visitor feedback showed that these were not noticeable enough, nor was it clear which distance was being measured (from the starting line? from the screen?). We made the switch to a color representation with a rainbow of tiles on the floor that corresponded to color bars on the computer screen. This enabled even our youngest visitors to start to interact with the exhibit and to quickly grasp the relationship between their position on the floor and the line on the screen by simply matching colors. The graph on screen continued to use numbers to indicate the number of seconds passed on the horizontal axis.[4]

Figure 6: Colored floor tiles helped visitors map there position to the line on screen. Photograph courtesy of the Science Museum of Minnesota.

In early tests, some visitors were unclear where to stand. Some started with their backs to the screen. Adding footprints on the tiles and changing the position of the “start” button helped visitors orient themselves and helped them connect their physical motion to the graph more quickly.

How does Partner Motion Attempt to Support Mathematical Understanding?

In the design of the activity itself, we asked visitors to move with their whole bodies and to see how a graph line of distance vs. time would respond in real time. By building in a kinesthetic way to engage with this graphing activity, our hope was that we would allow visitors to access formal mathematical understanding in a new way, through body motion. We also hoped that the visceral appeal of these would make someone want to come back and work with this exhibit again.

Visitor testing was a crucial part of the exhibit development process. We learned early on that this activity was very engaging for visitors and that it had potential for people to develop a qualitative, intuitive understanding of slope. When asked how they had matched a graph, two teen-aged boys replied, “The faster you move forwards, the faster the graph goes up.” Our testing focused on improving visitor conversation with each other and with group members watching from outside, as well as developing challenge questions that focused the conversation on the math. We also experimented extensively with the hardware to maximize the clarity of the signals from the two sensors. In addition, the formative evaluation informed the development as well as testing exhibit prototypes with colleagues on the floor at the Museum of Science in Boston, and with colleagues from the Math Core project.

What Did Visitors Think They Were Doing?

In some cases, visitors saw physical connections to math. For example, when an interviewer asked some young visitors, “Would you describe for me what you did at this activity?” one 6-year-old boy said, “I walked and tried to follow the graph.” A 5-year-old girl said, “The speed of how the line went.” One particularly math literate visitor described what she was doing this way, “It looks like my calculus graphs. … It’s helping you figure out rate of change, 2nd derivative.”

In other cases, people saw this activity as a chance to move in space, which is related to geometry and proprioception, but not directly to rate. When parents were asked by an interviewer, “What would you say the Museum is trying to show with this activity?” one mom replied, “I’m a massage therapist — [it’s about] how we move — the science of how we move.” Another mom answered, “Looking at screen and knowing where you are in space. I teach and kids don’t know where they are in space.” In answer to the question, “What could we do to make this activity better?” one adult replied, “I never considered movement from that perspective. Anything that educates people on how we move (is great…).” One visitor said that the most interesting thing about this exhibit was thinking about how you use your body to make something spatially. Another said they thought this exhibit was about “solving puzzles using your brain and your body.”

Is This “Math”?

In what sense can mathematical thinking be a body activity? What actions indicate visitors’ understanding of how the graph responds to their motion? What actions indicate understanding of slope or rate? Visitors completed some of the challenges posed without necessarily describing in words how they did this. What does this tell us about their mathematical understanding? In other words, how could a visitor’s motion show us that they “knew” the math? Sometimes our bodies have knowledge that may or may not be able to be articulated. At this exhibit, visitors were able to move in such a way that they would match the colors on the floor with the colors on the screen as well as match the general shape of the graph itself. For example, when a visitor completes a challenge such as drawing an elephant with a partner, this type of visitor motion indicates a qualitative, kinesthetic understanding of slope.

When asked about what type of math visitors saw while trying Partner Motion, one said, “The faster you go, the faster the graph changes.” Another said, “Speed; some relationship between motion and the graph being made.” This indicates a basic understanding of a qualitative connection. Yet there were others who said they weren’t thinking about math at all. Perhaps they meant in a quantitative or numerical sense.

In formative evaluation data collected at Partner Motion (Wright & Parkes, 2010–2011), we asked people about discoveries they’d made. Some visitors were able to articulate in words what they learned. For example, one visitor said that the faster they move, the faster the graph changes and that staying in place makes horizontal lines. Another visitor said, “We discovered that the lines on the floor relate to the scale on the graph.” When asked about the kinds of math ideas that they tried, one visitor replied, “Speeding up or slowing down will make the slope steeper or flatter.” This exemplifies a more specific verbal connection between body motion and graphing that we had hoped a visitor would also come away with.

In general, this exhibit was more successful at developing a qualitative type of understanding than a quantitative understanding. Many visitors learned to create and interpret graphs of linear motion, using concepts of rate. They were able to make the graphs they intended to make. At times their understanding was embodied, and in other cases, it was also articulated verbally. According to Goldin-Meadow (2006), “Gesture thus lets speakers convey thoughts they do not have words for and may even play a role in changing those thoughts.”

If a visitor does the activity, but is not articulating how they did it, does that show evidence of mathematical understanding? From our perspective, yes. People experienced an important connection between motion and graphing that had to do with rate of change (for example, when they made an elephant) even when they may not be able to describe how they did it. While we hope that people will become more articulate in their descriptions and even in writing numerical equations, this sense of qualitative, intuitive, kinesthetic understanding of motion is equally important and traditionally left out in school mathematics. In the end, it depends on what one “counts” as mathematical understanding. If *Math Moves* has broadened people’s understanding of what counts as mathematical knowledge, then it has done its job.

End Notes

[1] In this article, we refer to bodily kinesthetic learning, but recognize that others use related terms including embodiment or embodied cognition.

[2] The content focus is the broad topic of ratio and proportion, including fractions and the geometric concept of similarity, with exhibits that are: 1) Open-ended to encompass several ways visitors may interact and often more than one math problem to explore, 2) Conversational to encourage children and adults to talk with each other about the exhibit activity, and 3) Accessible by incorporating audio and written labels in English and Spanish.

[3] All visitor quotations are from our formative evaluation (Wright and Parkes, 2010–2011).

[4] A color version of this paper is available through the CAISE website at informalscience.org under the MathCore project.

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Acknowledgments
The authors would like to thank J. Newlin and Andee Rubin.

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Middle of the Road: Respect or Self-Censorship?

By Jan B. Luth

For science centers and natural history museums, evolution seems like a fitting topic for engaging our audiences. But in a growing number of communities around the country, the subject of evolution is hotly debated and politically polarizing. Is there a way for a museum to find a balance to serve their entire community when some disagree with aspects of accepted scientific thinking, such as evolution? That's what Exploration Place faced in Wichita, Kansas. Would we be able to find a middle ground to be welcoming to families with a different world view?

We had to get our arms around the character of this community and its concerns with the museum. A local elected official, who believed in our museum's pledge to find middle ground, helped immensely. As part of this community group he generalized the character of the individuals as those who do not believe in evolution, extended geologic time, climate change, vaccines, abortion or fluoridated water. He also shared some key museum history that had sparked dissension.

He explained that one of the museum's founding donors was a Wichita doctor who conducted late-term abortions. His name on the founders' wall led to a letter writing campaign and an unofficial boycott of the museum by anti-abortion supporters. Then in 2006, Exploration Place hosted the traveling exhibit *A T. rex Named Sue*. Not all staff stationed in the exhibit had been sufficiently trained to handle visitors who might challenge extended geologic time. There were some contentious interchanges that rippled through this community.

Over the years, staff had tried to reach the very large home school audience in south central Kansas but those efforts fell flat. Equipped with history, insight and the support of an elected official, it was time to try again. We knew we needed buy-in from the community. To be successful, we knew we had to be sincere and they had to believe us. With the help of the elected official, we formed a Home School Advisory Committee, many of whom were leaders and all were aware of the issues described above.

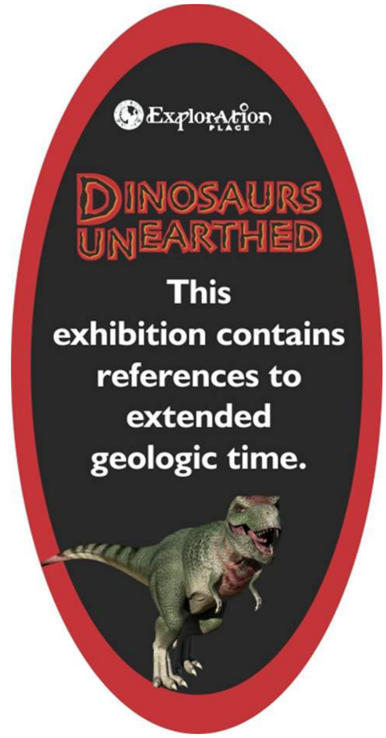

Figure 1 (Left): A "warning" sign at the entrance to the dome theater, which states that the film references extended astronomical and geological time. Figure 2: A sign posted at the entrance to the Dinosaurs Unearthed *exhibit indicates to visitors that the exhibit references extended geologic time.*

The first two meetings encouraged open conversation, acknowledgment of the past concerns, with an eye toward the future. How could our museum serve their needs? Can we go forward? We were clear about our boundaries. I made a personal commitment that our museum would be respectful of a different world view, but we would not sway from our institutional commitment to align with accepted scientific research of the field. We would not teach and interpret ideas and notions contrary to those. We would find a balance.

With the Home School Advisory Committee's guidance we developed an annual plan of offerings with semester themes. We started with a safe one – engineering. Then, as our audience built and we gained their trust, we expanded to astronomy, meteorology, human body, math, biology and geology. We have been a vendor every year at the annual state conference of the Teaching Parent Association where we sought feedback and ideas from those attending. And this year, we started advertising on some Christian radio stations.

To stay true to our word that respect would prevail, we conducted staff training for all frontline, education and reservations staff. The key points: treat everyone with respect no matter what their view point, don't get argumentative or defensive, don't try to convince anyone of your view point, and under no circumstances debate. Keep it simple. Just thank them, acknowledge that people have different views, and just state that our museum presents current accepted scientific thinking.

Some Middle of the Road examples:
For exhibits and films in the dome theater, we had "warning" signs with simple verbiage that indicated extended geologic time was presented. Those who do not believe could make a choice – not to go; or go and use it as a personal teachable moment with their child. For the 2013 exhibit *Dinosaurs Unearthed* the museum only received two formal complaints that we were pandering by having such a sign near the exhibit entrance. I personally addressed those, explaining that we were being respectful of the diverse thinking in our community in an effort to serve all. We had great attendance from our entire community including home school families and received no other complaints.

This semester the theme for home school programming is geology. The monthly topics include: Rock ID, Gems and Minerals, Plate Tectonics, Weathering and Erosion. But what are we not addressing in these classes – extended geologic time. However, staff are prepared to be informative should the topic arise.

At our museum, we believe we have found a balance. We are the largest science center in the state, and we feel strongly that we need to be approachable and welcoming to all of the citizens. We can't alienate any groups with adamant positioning. We want to engage and inspire all children in our state to embrace science learning. We believe this balance enables us to serve a large population and be open for all residents in south central Kansas. Those in much larger metropolitan areas with enormous populations, or in communities and states with progressive thinking may feel you don't need to compromise to grow and sustain audiences. You may be critical of our position and feel we are implementing self-censorship. You may be right. We are walking a fine line. But for now it's working, and we are achieving our goal to reach a broader audience for the museum.

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> **"We are the largest science center in the state, and we feel strongly that we need to be approachable and welcoming to all of the citizens."**

Science Learning Opportunities from Viewing Agricultural Dioramas in the Science Museum London

By Sue Dale Tunnicliffe and Jane Insley

Introduction

The diorama as a display technique is found in a wide variety of types of exhibitions. As the subject of academic study, biological/habitat dioramas have arguably received the most attention – by Reiss and Tunnicliffe (2011), considering them as essential learning tools, and more recently by Tunnicliffe and Scheersoi (2015). A brief survey of available literature indicates the role dioramas play for the visitor to an exhibition and recent approaches to pedagogy associated with this. Here, we widen this debate to STEM, using an example of a conceptual scene in the Agriculture Gallery at the Science Museum, London. This shows the potential for use of the diorama for a much wider range of educational possibilities than might be supposed from its exhibited location. We suggest this is a novel but accessible approach to assisting learning in an intriguing and inspiring manner.

A Neglected Learning Tool

The science content diorama is a much neglected tool for the learning of science. Dioramas are minds-on exhibits as opposed to the hands-on types found in science centers, where the physical interaction frequently becomes the exhibit. The computers in many hands-on exhibits can be interacted with elsewhere, such as in the home.

In the last quarter of the 20th century, the development of science centers proliferated. Bradburne (1998) suggested this was a direct effect of the space race between the USA and the USSR in an effort to interest the public again in science. Furthermore, science centers focused on designing exhibits that involved visitors physically rather than the traditional passivity. He also pointed out that hitherto the role of a museum had not been to render science accessible in a popular manner, but rather to record and archive phenomena (Hein 2000).

Moretin and Guisasola (2014) maintain that visits which contain activities designed to be performed during a visit at exhibits, as well as school-based activities before and after a visit, are an integral part of learning. Well-designed visits with activities that can be done during the visit itself as well as pre- and post-visit activities to be done in the classroom that are linked to the curriculum can considerably increase student motivation and learning (Osborne & Dillon, 2007). Tunnicliffe and Scheersooi (2010) maintain that, "The focus of intervention initiatives should be on accurate minds-on observation rather than physical hands-on manipulation of objects and invite questions from the observer."

Visitors attend museums, and hence those with dioramas, with a variety of agendas—as a conscript taken by someone as part of a curriculum-focused school visit, as a member of a family outing, or as a free choice learner who almost by definition has to be solo. The conscripts make the visit predominately at the request of a companion or adult with a target. Falk (2009) quoting Theano Moussori's investigation of motivation for museum visits, remarked that most visitors mentioned that they visit museums in order to learn something. We suggest that for the conscripts, the diorama offers potentially appealing opportunities for STEM learning. Braund and Reiss (2004) remark, "Many educators, particularly in the past, have sought to justify and promote a variety of situations outside the classroom in which school-aged children might learn".

Visitors respond to dioramas with distinct patterns of behavior. Initially they identify the specimen, name it, and often comment on a salient feature or structure. At dioramas, they also describe behaviours and make affective comments. If their interest is caught, they start interpreting the scene presented, mostly in anthropomorphic terms, seeking to relate the subject to what they know and understand. Visitors rarely read the information provided by the museum text panels, and tend to interpret at the level of their biological knowledge, which is generally basic. They may raise questions about the subject, ask why, how, and what and construct hypotheses. In most cases, this typical biological dioramas interaction sequence occurs: identify – interest – interpret - investigate (Tunnicliffe and Scheersoi, 2010); however, the order of these four typical activities may vary. If we analyze the content of dioramas, we can then develop minds-on activities to assist the learner in interpreting the scene portrayed and learn about the science illustrated.

A New Approach to Studying Dioramas

We propose a different approach to engaging learners in aspects of science through viewing constructed, historical conceptual dioramas. Our focus is on constructed dioramas that contain elements of physical science and biology, which can be identified and learned in a minds-on interactive way with the use of facilitators, either hand held guides or people. Dioramas are ideal venues for developing the inquiry approach (Scheersoi and Tunnicliffe, 2007).

None of the research cited has considered identification of biological and physical science exemplars as science learning opportunities in constructed dioramas that tell stories— in the case of the diorama considered here, from the history of science. This type of diorama features firmly in the museum world as key exhibits with tremendous, but often underused, educational potential. They are minds-on exhibits as opposed to hands-on, in which the physical interaction frequently becomes the exhibit. Dioramas are windows into both the natural and human-constructed worlds, usually of the past. Such dioramas hold a fascination for visitors. The dioramas under consideration are conceptual dioramas—not of specific historical scenes and not based on an actual location and event. This is unlike the Carl Akeley African dioramas in the American Museum of Natural History New York (Quinn, 2006), where tremendous effort was put into making the scene as authentic as it had been when the central taxidermied exhibit was collected.

Several researchers, e.g. Tunnicliffe and Scheersoi (2010, 2015), are interested in what message visitors take from dioramas. There are various ways of eliciting such information: questioning, open interviews and recall post visit through telephone conversations, and pieces of writing or drawing. For example, Mifsud (2015) describes a technique of comparing drawings executed by children before and after a visit to natural history dioramas to determine prior knowledge and expectations, and then to find out what they remembered and how they interpreted the dioramas they saw.

A Case Study of One Diorama.

We focus on the medieval ploughing diorama from the Science Museum, London to illustrate our point. The main feature in the diorama is a team of four oxen, towing a wooden plough, for a team of two men. Two other people in the background are breaking up larger lumps of earth with mallets. Behind them, a pile of waste is being burnt, and opposite, another group is harvesting ripened crops. In the background is a small village with dwellings clustered around a church with a tower; other animals are pastured in fields near the buildings, and in the distance to the left, the road clears a river with a hump-back bridge, and an undershot water wheel runs on the stream, probably to grind corn. Along the road, some pack animals are carrying loads.

Physics and engineering points can be recognized as can aspects of biology. Technology features strongly, in the construction of tools and objects needed for everyday life such as clothing and machinery, and which utilize both man-made and natural occurring items.

Concepts Identified

The following science concepts can be identified in the diorama.

Physics Examples

1. The pull on the plough from the oxen;
2. Pushing on the plough handle by the man to steer it;
3. Clod crushing with mallets;

Figure 1: Diorama showing ploughing in medieval times, Science Museum, London.

4. Balance of forces: by the man steering, in the design of the plough so that the height of the tow-rope point is optimal for the draft animals;
5. Tension in the rope used for pulling;
6. Friction in the twisted strands comprising the rope.

Technology Examples

1. Forces used in combination with heat, such as the rivets in the ploughshare, fastening the blade to the uprights;
2. Use of fire, not only for forging the rivets;
3. Shape of the ploughshare to turn over the strips of soil cut up by the plough; the form of the furrows for drainage and to take the seed later; the curve of the bar of the plough; the yoke and harnesses of the oxen;
4. Forming joints: making the rope out of strands; the formation of the fence – horizontal bars which slot into holes in the upright posts (palings);
5. Cutting: the plough; sickles being wielded by another team of people in the cornfield to the left; twisting stalks of corn to tie the cut stalks into a sheaf;
6. Control: the oxen are guided by a second team member holding what looks like a long whippy willow stick; there may also be voice control. Fire is used as a tool in the background for controlling weeds – a small bonfire on the right.
7. Transport: People walk, or ride in carts; the goods are carried in carts or by pack animals (donkeys). The animals need harnesses, made from rope or leather, probably with small pieces of metal as fastenings. The road surfaces are prepared, however roughly, and pass between banks or fields.
8. Construction: the church is stone – shaped masonry, cemented together. The houses are thatched – the roofs are less durable than stone, but readily and cheaply repaired when necessary. Thatch is a good insulator, and keeps in the heat from fires used for heating and cooking.
9. Tools visible in the scene include mallets, prods for the field fire, whips for the oxen and the donkey, and sickles.
10. Clothes: the four main characters wear clothes made

of cloth (possibly wool, possibly woven). All of them wear headgear; the season is probably autumnal.

Biology Examples
1. The types of soil, crops and vegetation.
2. The animals (male/female, hooves, horns, ear flaps, number of feet (4), tails.
3. In contrast, the humans are bipedal, and their eyes are both facing forward in the skull, where the oxen's face more to the side.
4. Remarks about opposable thumbs (to grip tools).
5. Body temperatures and clothing needs.
6. How muscles work.
7. Weeds: in the background is cavity for controlling weeds – a small bonfire on the right.

Contribution to Teaching and Learning Science
Identifying such observable phenomena is the starting point in cultural STEM, linking with learners and encouraging them to use their previous knowledge to construct understanding and ask questions. This can be followed up by designing and then testing materials for pre- and post-visits as well as planning cue questions for a facilitator before introducing these to chaperones and the teachers. The approach outlined here is a starting point to learning about science and technology in everyday life. This is a hitherto unpublished approach to STEM learning and should intrigue and inspire colleagues in STEM to use museums.

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Five of The 10 Weirdest Museums in the World

To celebrate International Museum Day, 2014, Time Magazine (Time.com) presented 10 museums around the world that are anything but mundane. Nos. 1-5 were in ILR 129;
here are nos. 6-10.

6. Momofuku Ando Instant Ramen Museum, Osaka, Japan
Millions of college students have Momofuku Ando, creator of Cup Noodles, to thank for the cheap meal that kept them alive for four years. The museum (http://www.instantramen-museum.jp/english.htm) dedicated to Ando and his culinary creation, even includes an instant ramen workshop where visitors can make their own "fresh" noodles.

7. International Cryptozoology Museum, Portland, Maine, USA
Cryptozoology is literally "the study of hidden animals" and involves the search for animals whose existence has not been verified, like the Yeti or Bigfoot. This museum's collection (http://cryptozoologymuseum.com) includes specimens and artifacts purportedly related to these types of mythical, unverified creatures. It includes everything from hair samples to fecal matter and native art — and it just might turn you into a Bigfoot believer.

8. Meguro Parasitological Museum, Tokyo, Japan
Learn everything you've ever wanted to know about tapeworms, head lice and plenty of other parasites you've probably never heard of. The collection (http://www.kiseichu.org/Pages/eaboutus.aspx) boasts 300 specimens, including a 29-foot tapeworm. Not recommended for anyone with a weak stomach.

9. Museum of Medieval Torture Instruments, Amsterdam, Netherlands
If you can forgive them for using Comic Sans on their website (http://www.tortureamsterdam.com/main/index), check out this museum for its diverse collection of more than 100 torture devices. Some you'll look at and say, "Okay, yeah, I see how that would work." Others will have you scratching your head wondering how the heck they were used and just how brutal the resulting torture was. Fun for the whole family!

10. The Kansas Barbed Wire Museum, La Crosse, Kansas, USA
Yes, there's really an entire museum (http://www.rushcounty.org/Barbedwiremuseum) dedicated to barbed wire. It features more than 2,400 varieties and explores the role barbed wire played in the settlement of the United States. We'll go ahead and recommend not touching any of the displays.

The Informal Learning Review
1776 Krameria Street, Denver, Colorado 80220

On the cover:

Immersive Media Entertainment, Research, Science & Arts (IMERSA) is an advocacy group for fulldome and immersive digital media, formed to help producers, artists, and hardware and software developers communicate, share, and promote their work, and create standards for production and presentation.

The rise of fulldome media since the last decade of the 20th Century has brought together performance and experimental artists to explore use of domed theaters.

Right: Fulldome theaters have been long associated with presentations about astronomy and space science. Image courtesy of InPark Magazine.

Full article on page 8.