INFORMAL LEARNING

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ENGAGING FACULTY SCIENTISTS IN K-12 EDUCATION COLLABORATIONS

Elizabeth K. Stage

2001 Nobel Prize winner Carl Wieman has attracted considerable attention in recent months by leaving the University of Colorado, where he has been for more than twenty years, to go to the University of British Columbia to focus on improving undergraduate physics education. In May, he visited Berkeley and his lecture, "Using the tools of science to teach science," brought an overflow crowd to the lecture hall; faculty and students were asking themselves, "How could a person with Wieman's research accomplishments walk away from physics research and devote the rest of his professional career to physics education?"

The main point of the lecture was that education can and should be improved by applying scientific methods-using evidence instead of anecdote, testing ideas with experimental trials, refining ideas systematically-and Wieman reported research from his group as informed by others in the physics education and broader cognitive science community. From my perspective as a science educator who has met more than a handful of scientists who think that their scientific accomplishments allow them to ignore the data in science education, this was a refreshing point of view.

As part of the visit, Wieman visited the Lawrence Hall of Science. The "Hall" is a public science center and organized research unit; our mission is to inspire and foster learning of science and mathematics for all. We incorporate research about teaching and learning in our development of exhibits, programs for the public and teachers, and instructional materials that are used widely across the United States and increasingly internationally. Hall staff work very hard to involve scientists in our work for a variety of reasons; involving faculty helps us to improve the quality of everything that we do, particularly to fulfill our goal of

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CREATION MUSEUM NOW OPEN IN KENTUCKY

Robert Mac West

The newest "museum" devoted to demonstrating the literal truth of Biblical creationism opened in Petersburg, Kentucky (a suburb of Cincinnati), on May 28, 2007. Owned and operated by the evangelical creationist ministry "Answers in Genesis," The Creation Museum is a $27 million, 60,000 square foot confabulation of a natural history museum and a life-sized, three-dimensional illustration of the book of Genesis. I visited on July 5, five weeks after opening, and thus saw it in reasonably typical operating mode.

A Triumph of Form over Substance

The museum sits adjacent to Interstate Highway 275, only a few miles from the Greater Cincinnati International Airport and, as AIG explains, within a one-hour flight or a one-day drive of two-thirds of the U.S. population. It is an imposing colonnaded building with a huge parking lot in front of the entry plaza, which is dominated by a life-sized, well-photographed, model of a sauropod dinosaur. The property is entered through a gateway dominated by sheet metal outlines of a *Stegosaurus*. The museum is flanked by a well-landscaped garden/park/picnic area, replete with dinosaur, bird, and sea-monster topiaries.

After purchasing their tickets in a well-managed queue, visitors enter the main gallery, also dominated by dinosaurs, this time animatronic. Here is where the natural history museum first runs up against the Bible: in an impressive open diorama, two animatronic human children are happily playing alongside a pair of juvenile carnivorous dinosaurs (obviously, a scene from before the Fall). This is the form of a natural history/science museum with the substance of Biblical infallibility.

Therefore, the die is cast – dinosaurs, paleontology, and geology are the tools for demonstrating the literal truth of the Bible and the egregious errors and, in fact, dangers of modern evolutionary science. And the Creation Museum uses all the tools of the modern museum to do so

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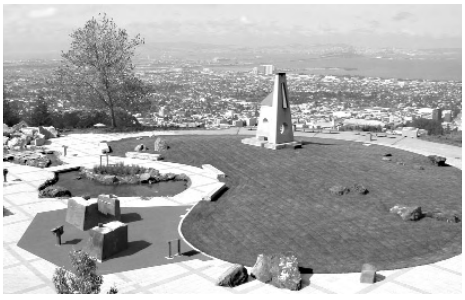
"K-12," continued from front cover

Carl Wieman

giving visitors a window onto the campus research and to provide a service to the campus. Sometimes we benefit economically from being written into a proposal; sometimes we use our core resources to make the collaboration possible.

Our most obvious examples of UC Berkeley faculty involvement are our exhibits; for example, Ian Carmichael, a geologist, conceived *Forces that Shape the Bay*, our outdoor exhibit that helps to explain our breathtaking view. Recently, Lisa Pruitt held the final exam for Mechanical Engineering 117, Structural Aspects of Biomaterials, on our exhibit floor by her having students explain the engineering behind hip replacements, heart valves, and dental implants. In our professional development institutes for teachers, it is not uncommon for faculty to give lectures on their areas of expertise; less common, but particularly valued, is mathematician Hung-Hsi Wu, who co-teaches with a teacher leader for a full month's session. Less obviously, but as important in improving quality, scientists like General Atomics' Larry Woolf review



Forces that Shape the Bay

drafts of our curriculum materials for their scientific accuracy before they are sent to publication.

Carl Wieman asked the Hall staff how we go about recruiting scientists for this work. Since he is focused on being systematic in the improvement of science education, he was clearly surprised by our answer, "One by each." Scientists are singular in their focus, have very definite and well-honed opinions; while there are some generalizations that we can share, the first is to form partnerships with individuals rather than looking for a formula. Since we ran out of time to elaborate, this essay could be viewed as a follow-up note to Professor Wieman and an open letter to other physicists who are interested in thinking about ways to involve colleagues in K-12 education work. As luck would have it, the Berkeley Outreach Roundtable met a few days later and that discussion of faculty involvement in outreach enhanced my thinking.

Incentives

For most faculty, the starting point for their involvement in K-12 activities is altruism, doing the right thing, particularly when it comes to equity and diversity goals, or evangelism, sharing their enthusiasm for the discipline and wanting others to share in the excitement. Many scientists like to spread the word to the public about the work that they do and how important it is. NASA was the first federal science-funding agency that realized that the survival of their public support depended on public understanding of the results of their missions; they have set aside a percentage of the budget for every scientific mission for Education and Public Outreach (EPO).

The National Science Foundation has also figured out that public support for research will diminish if only one hundred people can appreciate the results of the research that they fund; Criterion 2, "Broader Impact," is a placeholder for the idea that more than those 100 people need to appreciate the results of the research. By putting their time and funding into existing mechanisms, such as the Center for Science Education at Berkeley's Space Sciences Institute for EPO, or activities at the Hall or the Graduate School of Education in the case of Broader Impact, researchers can contribute to a larger enterprise, rather than doing some small thing on their own.

A different starting point may be the opportunity to share their intellectual assets at the same time as they are strengthening their research base, such as the Museum Informatics Project, where Berkeley's Natural History Museums are collaborating on a database that will enhance their research and other scholars', their teaching and other instructors', and have the intentional byproduct of making their collections available to the general public, with a special emphasis on teachers. The National Digital Library is a larger and more comprehensive example of a shared resource that benefits scholars and teachers.

Closely related to altruism and evangelism is intellectual engagement. One has to take advantage of any initial window of interest to get faculty to see how challenging education is, perhaps even more challenging than their discipline. K-12 work can give them an opportunity to try out their ideas about curriculum, teaching, and learning in a place that is more open, perhaps, than their own department. Berkeley's charter school, Cal Prep, is a place where faculty from a range of disciplines have become involved because it provides a test bed for innovation. Collaborations with the Hall provide another venue on campus that provides access to schools, teachers, and the public. Work in K-12 provides faculty with an opportunity to fulfill a service requirement, whether imposed by funding agency or encouraged by promotion criteria. It used to be said that you shouldn't ask a faculty member to work in outreach activities until he or she had attained the level of full professor, as such work would be considered negatively in promotion decisions. After years of debate, in July 2005, the UC Academic Personnel Manual added the following paragraph:

> The University of California is committed to excellence and equity in every facet of its mission. Teaching, research, professional and public service contributions that promote diversity and equal opportunity are to be encouraged and given recognition in the evaluation of the candidate's qualifications. These contributions to diversity and

equal opportunity can take a variety of forms, including efforts to advance equitable access to education, public service that addresses the needs of California's diverse population, or research in a scholar's area of expertise that highlights inequalities.

Contributions to equity and diversity were added to each of the promotional criteria—research, teaching, and service—including examples of activities that count as evidence. It is too soon to see if this explicit recognition is taken seriously by review committees, but it is certainly a step in the right direction, and should at least reduce the negative weighting assumed to have been applied in the past. (The section is available online at www.ucop.edu/acadadv/acadpers/apm/sec2-pdf.html .)

At some point, however, altruism runs out of steam, grants have been obtained, and promotions have been achieved; there's research to be done! For work in outreach to be sustainable, more compelling and systemic rewards have to be provided. One tangible reward is money for the faculty member, such as stipends, honoraria, or summer months. (You should investigate the rules for additional compensation for faculty within your institution before you make an offer that you cannot fulfill.) And, increasingly one needs to be careful to be accountable for money that is paid directly to faculty, to be able to say what it's paying for.

More important than money, *per se*, is money that gives faculty members support for their research and their graduate students. Course release, for example, can give faculty members time and can sometimes be bought out at a reduced, replacement cost, making that a win-win. Relieving a graduate student from being a teaching assistant for an introductory course for the sixth semester in a row is not only doing the faculty member a favor, it's providing the student with an opportunity to consider teaching and learning at a different age level and motivation. Money that allows the faculty member and his or her graduate students to attend and present at educational conferences will not usually be in the lab's budget, but can be considered a valued opportunity.

Strategies

- Listen for motivations. Some scientists are interested in fame and fortune, others are interested in "doing good" or becoming more effective educators. It helps to match opportunities to specified goals.

- Be the solution to somebody's problem. Individuals need to do something for "Broader Impact" or public service; department chairs and deans are looking for opportunities to support institutional goals of equity and diversity or more general public relations.

- Put your cards on the table. Partnerships are two-way; be clear about what you want or need from the scientist and what he or she can expect to gain.

- Use time wisely. Doing your homework about a scientist's areas of interest, even reading his or her publications, can allow you to make requests in specific areas of expertise. Don't let scientists spend their time on administrative duties; it's the surest way to dampen their enthusiasm. Do leverage their time by making an interview into a video, a piece of software, or a childrens' book so that they don't have to come in person to have their story told.

- Make it as easy as possible to get their feet wet, but bring scientists in early in a project, not to review at the end. They don't want to be stuck grading your paper after you've decided what the important concepts are and what activities or investigations best exemplify them.

- Ask! (and not just the usual suspects.) Before he went to the National Academy of Sciences to become its

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"Creation," continued from front cover

– well-crafted dioramas and immersive exhibits, numerous actual fossils, over 50 video presentations, high-tech theater and planetarium shows, and sculpted dinosaurs, both skeletal and fleshed-out.

This is by far the most professional and best marketed of the creationism museums scattered around North America, including one recently opened in Alberta, Canada.

Facts and Figures

- The announced cost of the building and exhibits is $27 million, all of which was privately raised. The museum claims that it opened debt-free. In addition, countless volunteer hours were donated to the production of the museum.
- The building is 60,000 square feet, with exhibits on two levels, the upper transitioning seamlessly to the lower.
- There are four theaters (including a special effects show titled *Men in White*, the Six Days of Creation Theater, the Last Adam Theater, and the Dragon Theater) and a 78-seat 3-D planetarium.
- Noah's Café offers both indoor and outdoor seating with regular and express service.
- The 49-acre property includes over a mile of walkways through gardens and quasi-natural areas.
- The annual operating budget is about $7 million, equally divided between admissions and sales on the one hand and contributions on the other.
- The place is pricey – $19.95 adult, $14.95 senior, $9.95 children 5-12; with the planetarium an extra $5.00. Annual and lifetime memberships are available.
- At the time of opening, the Creation Museum claimed some 8,500 charter members.
- The business model is based on an annual attendance of 250,000. The museum drew 31,711 visitors in its first month, plus some 9,000 who attended various soft openings. Opening day attracted 4,003.
- It is anticipated that 70% of visitors will come from over 250 miles away.
- The Director of Design is Patrick Marsh, formerly of Universal Studios Florida where he designed the *Jaws* and *King Kong* attractions.

What is "Answers in Genesis?"

"Answers in Genesis" is an independent, nonprofit, international ministry based in Petersburg, Kentucky, with headquarters at the Creation Museum. It originated in Australia and moved to the U.S. in 1994 with its president, Ken Ham, a former high school teacher. It has formally severed ties with the original Australian organization, which is now suing AIG over misrepresentation of its members' magazine.

The mission of "Answers in Genesis" is to "support the Church in fulfilling its commission; to bring reformation by restoring the foundations of the Christian faith which are contained in the book of Genesis; and to provide answers from Genesis and the rest of Scripture to make Jesus Christ, our Creator and Redeemer, relevant to the Church and world today." (IRS Form 990, 2005)

AIG employs about 300 people at its headquarters and in the museum. The most recently reported annual income is $5,429,923 (from June 30, 2005, IRS Form 990).

Before a person is hired in the Answers in Genesis ministry, or the Creation Museum, s/he must sign a Statement of Faith. According to the Answers in Genesis Web site, the worker agrees that s/he believes, among other things: that "Scripture teaches a recent origin for man and the whole creation," and "no apparent, perceived or claimed evidence in any field, including history and chronology, can be valid if it contradicts the Scriptural record."

The Presentation

The basic premise of this presentation is that there are two alternative ways of viewing the natural world, one correct and one incorrect. The correct one, God's Word, is laid out in Genesis and requires adherence to Biblical literacy, a six-day creation of everything by God, a massive change in animal and human behavior after Adam's sin, formation of virtually all of the physical features of the earth (e.g., the Grand Canyon, continental positions, etc.) and all fossils as a result of the Noachian flood, a 6,000-year-old earth, a spontaneously-created universe (as far as astronomers can now see and likely beyond), and acknowledgement of a multitude of social ills caused by mankind's rejection of Biblical truths. The incorrect one, Human Reason, is what is generally understood as science and, in particular, any form of evolution.

The required route through the museum (which is rigidly unidirectional once one leaves the Main Hall) introduces visitors to this dichotomy. The "Dinosaur Dig Site" shows two paleontologists, one a creationist (an older, bearded Caucasian man) and one an evolutionist (a younger Asian man), working on an excavation of a dinosaur skeleton but coming to very different conclusions based on their opening assumptions (the Bible vs. paleontology/evolution). Graphic panels here, and elsewhere, point out that we live in the present and have information, even about fossils, only in the present, and thus the past is open to immensely different interpretations. The gallery immediately following this reinforces this point by reference to numerous aspects of the scientific interpretation of geology and paleontology. Thus, the museum "presents both sides" as if science actually consciously considers the merits of "Human Reason" against "God's Word."

Shortly after this is a gallery that very bluntly and aggressively attributes the ills of current society (divorce, incest, pornography, secularism, teen pregnancy, racism, homosexuality, stem cell research, etc.) as a direct result of the rejection of God's word.

This is followed by an expansive diorama of the Garden of Eden (including an iguanodont dinosaur) in which Adam is naming the animals; in the next scene Eve is created from Adam's rib (no belly buttons visible). The next diorama is the fateful scene in which the forbidden fruit is consumed, followed by enormous

behavioral changes in dinosaurs (e.g., those with long sharp teeth now are meat-eaters), a behavioral change for Adam's family (they now have to farm for a living), and the introduction of pain and suffering (e.g., death, the pain of childbirth, etc.).

There then is a very impressive immersive area devoted to building the Ark, with animatronic Noah directing his animatronic laborers as they painstakingly hammer and saw to make the massive boat that will carry the created kinds of animals (no worry about plants – they floated as mats of vegetation which incidentally carried all insects as well) when God releases the Flood. The consequences of the Flood are laid out in the "Flood Geology Room" which graphically shows visitors how the Grand Canyon was formed, with examples of post-eruption erosion on the flanks of Mount St. Helens used to demonstrate how major geologic features (especially at high elevations) were brought into existence by the Flood and the subsequent retreat of the Flood waters (to where?). The gallery also discusses the flotation of continental plates into their current positions during the Flood. Post-Flood diversification (but not speciation) of life (e.g., horses from *Hyracotherium* to *Equus*, and all marsupials) followed when ecological niches multiplied as the world dried out

The final theater experience, *The Last Adam*, brings us Jesus' crucifiction and rising, with the ultimate consummation left to the visitor's imagination. Upon completion of that presentation, visitors are informed that there are counselors available to those who are in emotional need.

The linear exhibits open into the Palm Plaza, with an upscale coffee stand, which includes several cases filled with fossils that illustrate pre-Flood marine organisms such as Paleozoic ammonites, as well as numerous Eocene Green River fish specimens which purportedly confirm abrupt preservation as a consequence of the Flood. Adjacent is the Dinosaur Den, with models and skeletons of animals which existed during the Mesozoic Era (about 2,500 years ago), were obligatory herbivores prior to the fall, and which were included on the Ark (as juveniles) and did persist for a while after the Ark landed. It was in this area that I heard visitors talking about the live *Archaeopteryx* purportedly recently captured by the Smithsonian.

The stairs from the Palm Plaza lead into the Dragon Hall Bookstore. Here one encounters various logo merchandise (hats, T-shirts, etc.) as well as an impressive array of curriculum materials, books, videos, CDs, etc.

Observations

I must make a personal statement here. My PhD is in vertebrate paleontology, I taught paleontology and evolution at several universities as well as worked for several natural history and science museums, and devoted my scientific life to collecting and interpreting fossils and geology in the western U.S., northern Canada, and parts of Nepal and Pakistan. Thus, I feel qualified to evaluate the quality of Creation Museum exhibits (and assumptions) related to paleontology and evolution.

The Creation Museum is just what its name says it is. It is NOT a science museum, despite the trappings it assumes. It is an anti-science institution that deprecates hundreds of years of work by many thousands of scientists and asserts instead that the Bible is a science/history textbook, and that the results of intensive and extensive scientific research can be distorted to support a literal Biblical interpretation (one which, by the way, is not even accepted by all creation ministries/museums).

The "science" in this place is mind-numbingly bad. Not only does it reject virtually all of geology, paleontology, astronomy, biology, archeology and who-knows-what-else, but it attributes numerous negative aspects of modern (and historical) society to them. It appropriates the language of science to further a specific fundamentalist Christian agenda, implying that to accept evolution as the predominant theory explaining the universe, our planet, and the life on it is to be anti-God and anti-Christian.

That said, I find it perfectly acceptable for adherents of any religious perspective to makes themselves heard. What is both objectionable and deceitful is to portray those views in the guise of a museum, thus appropriating the hard-won position of museums, in the U.S. and worldwide, which have established themselves as places to experience the best and most accurate interpretations of science, art, history, and human culture.

"Answers in Genesis" has very effectively used public fascination with dinosaurs and other creatures of the past. Among their slogans are "Prepare to Believe" and "We're Taking Dinosaurs Back." This is a very effective use of scientific icons on behalf of a decidedly non- and anti-scientific message. To top it off, the entry lobby features a small-scale ceratopsian dinosaur with a child-sized saddle on its back – perfect for that great photo-op.

Interestingly, AIG realizes that the "museum" cannot rely upon the usual public school field trip audience. Given the highly religious nature of the message, public schools will not be able to use this facility. However, they anticipate it being a Mecca for home-schoolers and religious schools.

Finally, this "museum" is tapping into the significant portion of the American population that is predisposed to be non-scientific. Numerous recent polls indicate that half or more of the U.S. population accepts a young-earth creationist explanation in one form or another. Initial attendance at the Creation Museum appears to reflect this, in that the place is packed every day.

Publicity and Participation

The Creation Museum's opening attracted an astonishing amount of attention, both within the U.S. and internationally. Much of the international commentary was rather bemused, taking the form of "look at what those peculiar Americans are doing now." Within the U.S. it was a mix of curiosity about the resources being poured into creationism and deep concern about the Creation Museum as a metaphor for poor public understanding of science as well as the insidious influence of fundamentalist religion on society in general.

The museum was very busy the day I was there and conversations with several staff suggested that this has been the norm since opening. The afternoon entry queue was a hundred yards long, License plates

See "Creation," continued on following page

"Creation," continued from previous page

in the crammed parking lot indicated visitation from most of the eastern U.S. as well as several states well west of the Mississippi. People were enjoying their visits, despite the slow slog through many of the galleries, especially early in the linear experience. The audience that day included many extended families, seniors, and a surprising number of teens and twenty-somethings. Notable by their virtual absences were non-caucasians, though I did see a bus carrying a musical group from India.

Further information

Please refer to the following web sites for additional information and commentary:

http://travel.nytimes.com/2007/05/24/arts/24crea.html
http://www.washingtonpost.com/wp-dyn/content/article/2007/05/26/AR2007052600908.html
http://en.wikipedia.org/wiki/Creation_Museum
http://crazytalk.typepad.com/bluegrass-roots/2007/06/fun_at_the_crea.html
http://www.youtube.com/watch?v=Wzjjxi7f0Oc&mode=related&search=
http://news.nky.com/apps/pbcs.dll/section?Category=creationmuseum
http://scienceblogs.com/evolution-blog/2007/06/the_creation_museum_3_general.php#more
http://www.ncseweb.org/resources/articles/1411_the_antimuseum_an_overview_a_7_6_2007.asp

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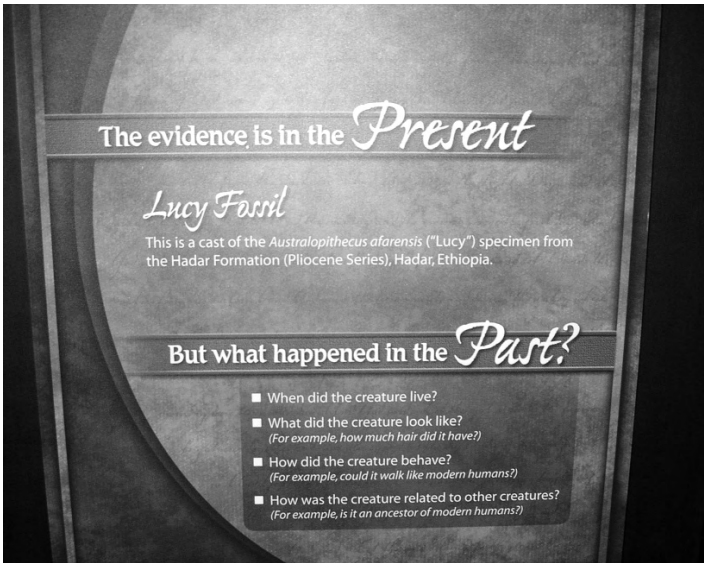
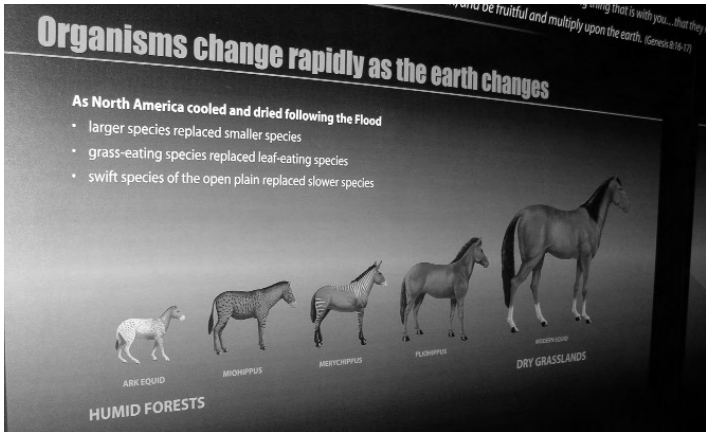
Entry Gate



Past vs. Present

Main plaza with dinosaur

Non-religious decadence



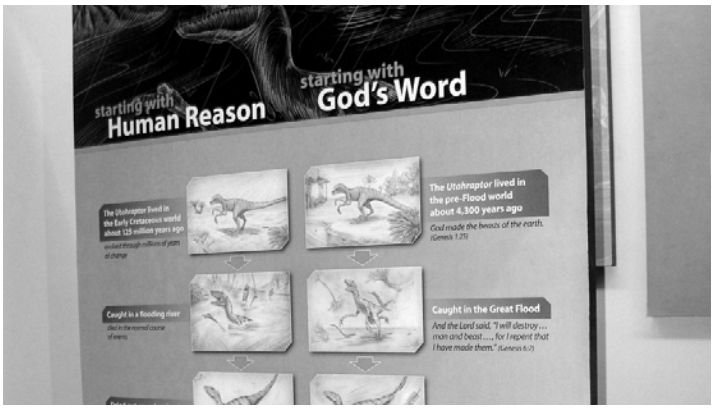
Post-flood organic changes

Deer and iguanodont dinosaurs in the Garden of Eden

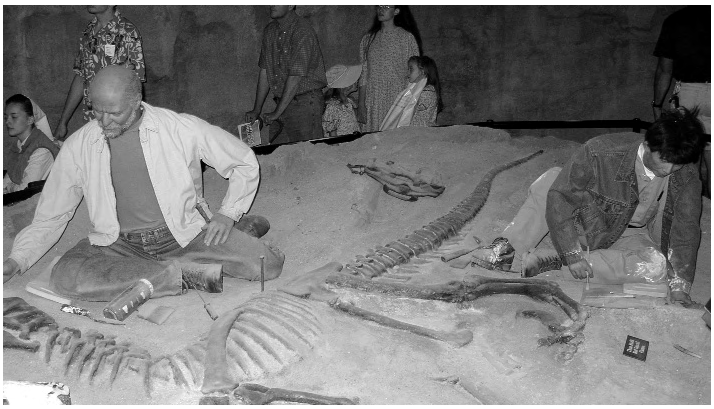
Building the Ark

Mount St. Helen's explains post-flood geology

Children with dinosaurs in Main Hall Diorama



Human Reason vs. God's Word



Dinosaur excavation diorama

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president, Bruce Alberts used to say that he never turned down an invitation from a teacher.

- Identify funding opportunities, such as NSF's GK-12, that allow sustained engagement.

- Document contributions, write thank you letters suitable for promotion cases, and otherwise celebrate success.

- Consider an institutional home. Many research institutes have outreach offices, such as the Berkeley Space Science Laboratory's Center for Science Education, Some universities, such as Stanford, have established offices to support faculty involvement in outreach, http://oso.stanford.edu.

Hopefully this article has provoked you to think about getting involved in K-12 education (it's both challenging and rewarding) or recruiting others to work with you. We are still learning at the Hall and I would welcome your comments or suggestions. You can learn more about the Lawrence Hall of Science at www.lawrencehallofscience.org.

Elizabeth K. Stage is the Director of the Lawrence Hall of Science; she may be reached at stage@berkeley.edu .

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NATURE MUSEUMS NEARLY RELICS THEMSELVES

Mike Boehm

The great American natural history museum could be headed for the vulnerable species list, alongside the polar bear and the redwood tree.

A national survey last year showed nature museums' annual bottom lines sinking chronically into the red by $300,000 on average, while art museums outperformed them by nearly half a million dollars. Some of the leading institutions have winnowed their staffs since the decade began, among them the Natural History Museum of Los Angeles County.

Natural History Museum of Los Angeles County

Science leaders worry that financial pressures and demands to boost attendance could prompt natural history museums to self-lobotomize, cutting away brain matter — the pure scientific research that's largely hidden from the public — to save the exhibits and educational programs that are the institutions' visible cash generators.

Research is what makes natural history museums special: the mandate to venture into nature and bring back new finds and fresh questions, while maintaining millions of specimens.

Some scientists say that amid global warming and a rapid die-off of species, these collections encompassing the world's life forms, living and extinct, have become especially valuable for the clues they might hold.

How have creatures through the eons adapted or failed as their environments have changed? What's happening now? Biologists say those questions are vital in coping with today's challenges, and they can't be answered fully without museum collections.

"With some major exceptions, there's been a 20-year retraction" in museum-based natural history research, said Leonard Krishtalka, who directs the museum at the University of Kansas. "We're slowly witnessing, by the whittling of curatorial positions, the extinction of incredible knowledge. For many organisms there are only one or two world experts, and they retire with no one to replace them."

Officials with the American Association of Museums, which conducted the 2006 survey that tags natural history as an underperforming sector, cautioned against drawing strong statistical conclusions, because the report was based on median results from 43 institutions over three years, compared with 197 art museums. But there's no shortage of anecdotal woe.

The Milwaukee Public Museum lies fiscally prostrate, its net assets having fallen to minus-$14 million last year, according to its 2006 tax return. The Academy of Natural Sciences in Philadelphia, the deficit-ridden, 195-year-old granddaddy of American natural history museums, sold some of the family jewels to prop up its finances last year, earning $1 million for a chunk of its mineral collection.

The Smithsonian Institution's natural history museum in Washington, D.C., which draws more than 5 million visitors a year and has the nation's largest collection, with more than 126 million specimens, is seen as deeply troubled; the staff has shrunk almost a third since 2000.

"It's a real concern to see continued diminishing ranks of scientists there," said Robert Gropp, director of public policy for the American Institute of Biological Sciences. "We hear routinely from folks who work there that morale is really down."

Even the American Museum of Natural History in New York, which stands with the Smithsonian and the Field Museum in Chicago as the Big Three of natural history exhibits and research, has had to economize. The museum has reduced its staff about 11% this decade, although curators were untouched, spokesman Steve Reichl said.

Universities aren't a strong alternative, scientists say, because many have given up their expensive-to-maintain natural history collections and focused their efforts elsewhere, including biomedical research, genetics and technology.

The Los Angeles museum, which vies with San Francisco's California Academy of Sciences for fourth place in national rankings, turned to shock therapy in 2003, laying off 7% of its staff to save $2 million and reverse a long string of deficits. Most remaining employees endured a wage freeze that ended this year.

The museum's scientists have been studying things like parasitical bee-killing Peruvian flies, or attempting to sort out the evolution and global distribution of gobioids, small ocean fish important to the diet of the seafood humans eat. How can such research fit into what investment company executive Paul Haaga Jr., president of the museum's board, calls "the elevator speech" — the pithy hook, deliverable in the course of an elevator ride, that's needed to recruit donors? And finding big donors is more crucial than ever for an institution that's revving up a $115-million fundraising campaign.

The museum's public face is simple enough to comprehend — the main building in Exposition Park, with its dioramas, dinosaur fossils and a darkened gem and mineral hall that glows like Aladdin's cave; and the George C. Page Museum on Wilshire Boulevard, showcasing extinct prehistoric mammals whose bones were dug from the ooze of the neighboring La Brea tar pits. Together, they draw 800,000 to 900,000 visitors a year; about a third are groups of children from public schools that get in free.

The harder part to explain happens on the third floor of the Exposition Park building. It's where most of the curators are — PhD scientists trained to go out in the world, find critters, critter remains and

anthropological artifacts and bring them back as specimens. The 33-million-piece collection is not shelved and forgotten but requires ongoing care.

"Collections are expensive to keep and are not revenue-generating," said the museum's Regina Wetzer, who studies tiny, bug-like crustaceans.

Joel Martin, the crustaceans curator, who has been at the museum nearly 20 years, worries that with every cutback, the chances to win grants worsen. Ambitious research often depends on scientists being able to win highly competitive grants from outside sources.

"They're not likely to put a lot of money into an institution that itself is not funding it," he said.

In the three years before 2003, the Los Angeles museum landed $2.4 million from the National Science Foundation. In the three years since, Los Angeles's share dropped to $1.6 million.

The austerity measures also snuffed what some saw as a promising youth movement that had begun in 2001, when four young biologists and three researchers specializing in the history, anthropology and archeology of the American West and Mexico were hired as curators. "It created a lot of energy," recalled one former curator, who asked not to be named for fear of alienating colleagues. "Research and collections was on the upswing, and the sky was the limit."

Now, just one of the seven remains. Kenneth Johnson, who studies coral reefs, went to the Natural History Museum in London; he noted dryly that it becomes easier to find opportunities when wages have been frozen.

The Los Angeles museum has 20 budgeted curatorial positions, down from 24 in 2000, and only 16 are occupied or being filled. The American Museum in New York has 42 curators, up from 39 in 2000.

Cutting curators was "like 'Sophie's Choice,' " said President Jane Pisano, but the museum couldn't keep outspending its income. This year's budget is about $26 million, with the county providing 45% of the funds.

Even with the cuts, about 24% of the natural history museum's spending goes to research and collections. Pisano noted that exhibits, education and other public programs got 23% combined. "Clearly, we need research," she said. "It lets us say, 'We create knowledge here.' It grounds our work."

There's nothing specifically for research, however, in the $115-million construction campaign. It addresses what the public sees: refurbishing the 1913 rotunda building and creating six galleries, including a near-doubling of the space for dinosaurs.

Experts even worry that the very name "natural history museum" has a Victorian tinge that makes it harder to compete for audiences and funding.

"It harks back 300 years and doesn't resonate anymore," said Leonard Krishtalka, the University of Kansas museum director who reclassified his venue as a "biodiversity institute." The challenge and potential salvation, he believes, lie in making visitors and donors understand the connection between the fate of the Earth and all those seemingly inert specimens tucked into drawers or arrayed on back-room shelves in jars of alcohol.

"Our collections and knowledge help inform solutions to the problems the planet's facing," Krishtalka said. "Our time is now, and museums that reach out and grab that mission strongly will be the ones who survive."

A completely rebuilt California Academy of Sciences is due to open next year in San Francisco's Golden Gate Park. The museum, which will have a "living roof" of greenery designed by Renzo Piano, could be the canary in the coal mine. If a leading institution that has had a chance to reinvent itself with almost half a billion dollars can't score a hit, the future for all natural history museums could be a real dodo.

Rendering of the new California Academy of Sciences

Driving the project, for which about $385 million in mostly private donations has been raised, was the realization that people had become bored with natural history museums, said curator John Patrick Kociolek, the former executive director who spearheaded the rebuilding. "Before you'd go, you could write down what you were going to see. The same stories were being told."

The new museum, he said, aims to stay fresh by uniting its public face with its hidden brain, clearly linking research to what visitors see by basing exhibits on the work of the museum's scientists.

For that to succeed, Kociolek said, there has to be a better exchange of ideas within the museum.

That's why Piano was asked to design hallways, office wings and other staff areas so that formerly "siloed" scientists would mingle routinely with colleagues in other departments.

Terry Yates, president of the National Science Collections Alliance, hopes environmental consciousness and civic competitiveness will light a spark among Los Angeles's philanthropists, who never have supported the city's museum of natural history on a scale approaching their counterparts in New York, Chicago and San Francisco.

The museum, Yates said, "continues to be a vital force on the West Coast, but it's facing problems. Do you want New York to continue to show up Los Angeles? Come on, guys, get going."

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THE POLITICS OF CREATIVITY: INTERACTIVITY AND CREATIVITY IN CONTEMPORARY SOCIETY

Dr. James M. Bradburne

PREAMBLE. This paper was first delivered at the Hands On! conference held in Milan, Rome and Naples in October 2003. Since then, the Next Generation Foundation was successfully launched in March 2004, and initiated a series of innovative projects, including the Map of Creativity and Making Playful Learning Visible (with the generous support of the Esmée Fairburn Foundation). Unfortunately, at the same time, the fortunes of the LEGO company (whose CEO Kjeld Kirk Kristiansen initiated the Next Generation Foundation) were suffering in the marketplace, and in 2006 it was decided reduce the ambitions of the foundation and to gradually transfer the operations of the company from London to LEGO's headquarters in Billund, Denmark. The website is still visible online, and discussions are underway to ensure that it remains a vital platform for innovative educators worldwide. The other projects originally imagined have been put temporarily on hold. Notwithstanding this setback, the views expressed in this paper remain valid, and Next Generation Foundation's calls for a 'creativity agenda' remain as urgent as ever.

The word creativity is notoriously difficult to define. The starting point is almost invariably innovation or novelty, but when confronted with the far-fetched, ridiculous or silly, most try to leaven the definition with a measure of utility. Surely mere novelty cannot capture the essence of Leonardo's helicopter, Mozart's minuets, or Van Gogh's *Sunflowers*. Nevertheless, when it comes to determining the extent to which a novel idea, invention or proposal is creative, the question of how much utility is appropriate becomes vexed. Creativity is often argued to be both novel and useful. I think this leads us into error. Creativity by definition is novel – even if it means a new rendering of a Bach cantata – but utility is a judgment that can only be passed with time. The utility of a suggestion (and by the old definition, its creativity) cannot be judged by contemporary measures. The use to which a novel idea may be put may lie – like so many creative ideas – far in the future. Oftentimes, the utility of a seemingly mad idea only becomes clear with time, as technological, social or political possibilities change to remove the constraints that stood in the way of its realization. What seems patently ridiculous today may be blindingly obvious tomorrow. Even so, surely creativity is more than mere novelty – truly creative ideas seem to manifest an internal coherence, and almost invariably, this coherence comes at the expense of internal tensions. Novel, yes, but also useful. Impractical, certainly, but also possible.

The Next Generation Roundtable, a panel of experts assembled in 1998 by LEGO Company and the House of Monday Morning, a Danish think tank, struggled with the challenge of defining creativity, and formulated a series of indicators for whether or not a project was creative. These indicators took the form of a series of 'twosomes' that tried to capture the tension between opposites that seemed to characterize creativity. Briefly described, the twosomes were: Balancing Utopia and Reality, Balancing Challenge and Support, Balancing Freedom and Structure, Balancing Variation and Focus, Balancing Individual and Collective, and Balancing Action and Reflection. Each pair gave rise to indicators that would allow researchers to spot creative projects.

Despite the thoroughness of the analysis, the result was nonetheless not completely satisfactory. The twosomes were an attractive way to describe the creative tensions in existing projects, but difficult to use predictively. How much Utopia did a project need to have in order to be considered creative? A little, a lot? None? The twosomes were even more unwieldy as analytical tools. Was a project unsatisfactory because it had too little Dystopia? Too much? Could the 'Freedom' of a project be reduced in order to improve it? At the end of the day, as effective as the twosomes were in providing a framework for specific indicators of creativity – things to look out for – the approach never really functioned as a grounded theory of creativity. Perhaps the problem wasn't in the approach – perhaps the problem lay elsewhere. Perhaps it lay in the way in which we look at the notion of creativity in the first place.

Creativity and interactivity both suffer from confusion between object and subject – exhibits are referred to as interactive, spaces and toys as creative. I think we can make our task much easier, and our work more effective, if we see interactivity and creativity as properties of users, not of things. People are creative, children are creative, creative people are able to find solutions to seemingly intractable problems.

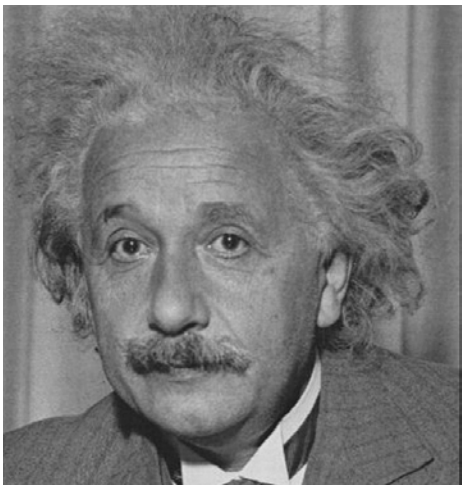
Let us look at this point in more detail.

Tools can certainly confer certain properties on their users. By use of tools, one can see farther, lift heavier weights, manipulate objects more precisely. By means of tools our voices can become louder, our eyes sharper, our arms stronger. Strength, accuracy, precision – these are properties that can be conveyed by tools. But creativity is not a property that can be conveyed by a tool. A creative chef works better with good tools. She is faster, more accurate, more productive. But a sharper knife does not make a chef more creative. A sharper knife allows a creative chef to imagine more possibilities.

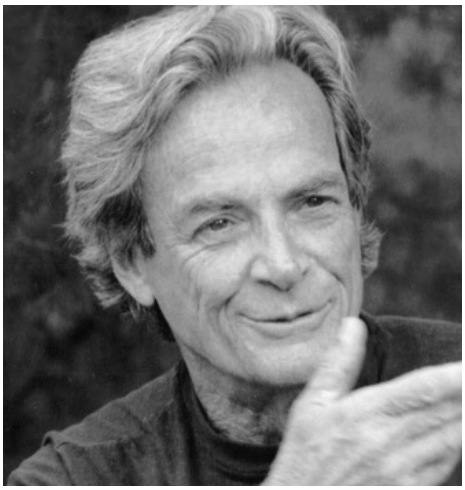
By the same reasoning, environments can certainly suggest particular uses, encourage certain behaviors, and support certain activities. But the most it can do is to provide a context in which the human actor can better explore the skills of creativity – which include innovation, imagination, risk-taking and play. A creative chef blossoms in a well-equipped and well-arranged kitchen, but the kitchen does not make the chef creative. Even if a new tool suggests a new practice or if the kitchen makes possible new preparations, it is the chef – not the tool or the kitchen – who does the cooking, and it is the chef who is creative.

Einstein often said 'imagination is more important than knowledge.' Nevertheless, he believed that it was critical, first, to grapple with a body of knowledge, to understand it in depth. This knowledge was not only the knowledge of physics 'for the critical thinking of the physicist

cannot possibly be restricted to the examination of the concepts in his own field,' but a profound reflection on the whole of knowledge. The tension, between the constraints of knowledge and creative freedom is at the heart of the scientific process – and of all creativity. Richard Feynman put the same point differently. 'The whole question of imagination is misunderstood by people in other disciplines. They overlook the fact that whatever we are allowed to imagine in science must be consistent with everything else we know'' Scientific creativity, he said, 'is imagination in a straightjacket.' Confronted with an unyielding mass of



Albert Einstein



Richard Feynman

marble, Michelangelo may well have though the same thing.

So what is creativity? I would suggest that the essence of creativity is the ability to innovate within constraints, and the ability to imagine ways in which constraints can be reduced, redefined, or eliminated to create solutions to user-defined problems – what Tom Bentley called desired outcomes. In effect, every creative act is a negotiation – with the physical world, the social world, and the world of ideas. Creativity – when seen as a property of human actors – is the way we describe the innovative negotiation between human desires and the constraints imposed by the environment. This environment includes the natural world, the social setting, and the legacy of past human activities we carry with us in the form of memory, culture and tradition. Creativity is masterful negotiation, and our goal as educators should be to support the acquisition of this mastery.

How Can Creativity Be Political?

If creativity can be defined, at least in part, as the innovative negotiation between human actors and the constraints they encounter, it means that both creativity (and interactivity) as human behavior should also serve human needs. Creativity itself need not be good or bad, but the uses to which creativity is put are human uses, and are therefore deeply political. To act politically means to act within a framework of values. Ideally creativity is innovation in service to a set of values – to the needs of society, to the well-being of the environment, to the cause of peace. While creativity can be put to terrible uses – the invention of new weapons or new means of enslavement, creativity tends to be a positive characteristic. Creativity demands that one imagine the world other than it is, and inherently mitigates against dogmatism, fundamentalism and extremism, which all tend to constrain thinking. Creativity is unusual as it has no imperative form. Like the verbs 'learn' or 'play,' it makes no sense to shout at someone 'create!' Creativity is instrumental – and inherently subversive – it does not accept the world the way it finds it.

In their 1969 classic *Teaching as a Subversive Activity* Neil Postman and Charles Weingartner argued that each student should have an 'automatic, built-in bullshit detector'. The educator and computer scientist Seymour Papert writes, 'as a political issue [creativity] has the potential to generate political conflict. Actions to promote creativity will have repercussions that will please some and displease others. For example, in some countries school policies are highly politicized with the consequence that attempts to modify school policies so as to give higher priority to the cultivation of creativity can run into conflict with partisan politics. It also runs into conflict with conservative ideas in education establishments about the relative importance and priority of issues, with the cultivation of creativity often being eclipsed by the teaching and testing of rote skills.'

There are many arguments in favor of supporting creativity in both children and adults.

The first and most common argument is that creativity represents a personal value. Individual creativity is without a doubt a source of fulfillment, pleasure and inspiration. Children encouraged to explore their creative skills and undertake activities in which their creativity is valued, often develop to be healthier, well-adjusted and happier adults. Our world is enhanced by the output of creative individuals. Living in a world filled with the products of creative individuals – culture – is something most people enjoy.

The second argument, fashionable in the last decade of the 20th century, is that creativity is indispensable for the new economy. The argument runs as follows: With information – notably in the form of business-to-business 'e-commerce' – playing an increasingly important role in delivering products more effectively and more efficiently, we have seen the European economy moving from a product-based economy toward a service-based economy – much as it earlier moved from an agrarian economy to an industrial one. In a sense we could describe this as a shift from a 'high-volume' economy, wherein industry makes a lot of products and sells them each at a profit – to a 'high-value' economy, wherein profit is made by being more flexible, more responsive, more creative. If we are to continue to justify our Euro-lifestyle - and pay our Euro-taxes - it is imperative that this shift toward a high-value economy be made as quickly as possible. It is now taught in management schools that, in the words of Arie de Geus, 'the only sustainable competitive advantage is to learn faster than the competition.' The market now clearly favors brains over brawn (as can be seen by the market value of a firm such as

See "Creativity," continued on following page

"Creativity," continued from previous page

Microsoft) – and the skills needed by the new workforce are those of flexibility and the ability to respond to change, but above all, creativity.

A third, and in my opinion compelling, argument has gained in strength with rise of fundamentalism. Creativity by definition demands that the creative actor imagine the world other than it is. Even a musician preparing to deliver a faithful rendition of a Bach fugue must imagine it in myriad ways before choosing to play it in a particular way. Creativity mitigates against dogma. Creativity gives free rein to questions and questioning. Why can't a person fly? Why must grass always be colored green? Why can't the world be other than it is? Creativity is the opposite of fundamentalism – it welcomes difference, it embraces change. Creative people can be very threatening. Educator Seymour Papert writes 'It cannot be overemphasized that a society based on creativity may challenge fundamental educational concepts. In a slowly changing society schooling can be designed to provide youth with the skills they will need for the jobs they will do. *The goal could be to produce citizens who can do what they were taught*. In a rapidly changing society where most people are doing jobs that were not invented when they were young a different need may become decisive: *citizens who can do what they were NOT taught*.'

Almost certainly, creativity cannot be taught, at least in the sense that mathematics, geography, or history can be taught. Nevertheless, if creativity is seen as a property of actors, then, like music or art, it can be encouraged. Settings can be designed that provide tangible rewards for seeking innovative solutions. Objects can be designed that encourage the development of the imagination. Opportunities can be constructed in which the barriers to imaginative play are lowered. I would like to briefly give a few examples of ways in which the skills of creativity can be encouraged in different contexts.

In 1990 the Canadian anthropologist Drew Ann Wake and I were invited to develop a new gallery on the earth sciences for Science World, a large science center located in downtown Vancouver. It struck us that there were two clear alternatives to tackling the subject. On the one hand, the earth sciences could be treated as they have been in traditional science centers. Visitors would learn about geological time, the development of rocks, faulting and continental drift. Following the example of other science centers, we could link geological themes to newsworthy geological events that captured the public's interest - volcanoes and earthquakes. By treating the earth sciences as a subset of geophysics, we would follow a traditional path: separating scientific fact from social issues.

The alternative was clearly more challenging. Instead of an exhibition on the earth sciences, we proposed to look at how the geological sciences are applied in a political and economic context: in short, we suggested an exhibition on mining. This exhibition, entitled "Mine Games," would deal with the issues surrounding the mining industry in our province, issues that have been increasingly the subject of heated debate in the

Science World, Vancouver, BC

press, on television, in parliament, and in the streets. This single change - from earth science to mining - entailed a complete re-examination of the way in which the exhibition would be planned and designed. With a mining exhibition, we could initiate a debate about the future of the province, teaching visitors to evaluate scientific positions arrayed in support of any number of competing positions. An exhibition on mining would call into question the role the science center should play in the life of the community, suggesting that the role of the science center is to prepare visitors to participate in the social and political life of their community.

The exhibition was designed as a series of games to enable the visitor to advise a fictitious community on whether or not to allow a mine to proceed, and culminated in an interactive voting theatre called "Hotseat!" Visitors were given the opportunity to learn a wide range of scientific information, not all of it in agreement. They were invited to explore this information through debate and develop skills that would help them to understand, and to alter, the political process in the province. As a consequence, Science World became the focal point of a unique social experiment that lasted over three years.

In May 2000, the Museum for Applied Art in Frankfurt was 'relaunched' as mak.frankfurt. As part of its Digital Craft program, mak.frankfurt developed the kids.in.motion project. The project had four phases in which the children worked with dancers of the celebrated Ballett Frankfurt, under the leadership of choreographer William Forsythe, and with digital artist and educator Paul Kaiser to explore the quality and nature of their own movements. At first they imagined all the different ways they could cross a room – they could squiggle, squirm, slither, skibble, skip or scoot, they could hop, hobble, harrumph or handspring. They then explored how to translate these movements into LOGO procedures – operations that can be performed by the LEGO Mindstorms building system (donated to the project by LEGO, which will also provide advanced programming assistance).

The children then constructed Mindstorms robots that combine these movements into sequences, exploiting the system's unique use of sensors to allow the robots to respond to touch, light, heat, and movement. The program was so popular that it was invited to participate in dance expositions combining children and robot dancers, in particular the 3rd World Summit on Media for Children in Thessaloniki, Greece, in March 2001.

Let me give you a final example. In my office in Frankfurt was a vitrine, specially designed for the Richard Meier monument of which I was steward. In the vitrine was a selection of beautiful glasses, from a 16th century Venetian masterpiece to a set of Boris Sipek glasses. I often used the vitrine to test new text panels – after all were not a hands-on center! I had one text panel with the title 'Glasses through the centuries'. It is amusing, informative,

and written in a popular style. Visitors to my office often stop to read it, and chuckle at the humor. I also had another text panel, with another title. This title read 'One of these glasses is a fake'. The difference in behavior was striking – often visitors stood for ages closely inspecting the glasses. Nor is the question trivial– after all, what is a fake glass anyway? All that has changed is the direction of the learning process – from top-down, to bottom-up. It is important to emphasize that interactivity and creativity are in the mind – not just in the hands.

What the three examples above all have in common is that they deliberately created settings in which the creativity of the user was encouraged by posing challenges that were relevant, and their ability to innovate enhanced by recognizing their capacity for independent action.

Making A Map Of Creativity

In 1998, the Next Generation Forum was formed by the LEGO Company and the House of Mandag Morgen with the "aim of creating among central decision makers in society, a new global commitment to children's learning, creativity and imagination." The purpose of this initiative was to explore the idea that children are a largely undiscovered human resource in modern society, that their potential must be set free, and that opportunities for children's learning and creativity must be expanded as the world enters the 21st century. An international group of experts within the fields of child development and education, including Carla Rinaldi, Seymour Papert, Mitch Resnick and Dorothy Singer was formed to provide perspective and direction on Next Generation Forum's strategy and activities.

Called the Next Generation Round Table, its aim was to prepare and discuss the drafts for the first Next Generation Annual Report, to prepare an agenda for the first Next Generation Summit, and to serve as the expert panel and advisory group for the secretariat and the LEGO Group in the planning of the Next Generation Summit. In 2001, the Next Generation Roundtable proposed that an independent, non-profit foundation be established in order to better fulfill the mission of the Next Generation Foundation. This proposal was accepted and I was hired to establish and direct the Next Generation Foundation as a private initiative of Kjeld Kirk Kristiansen, LEGO's owner and CEO.

The Next Generation Foundation exists to promote a 'culture of creativity' by providing exceptional educators working in marginalized communities with opportunities to learn new skills, by supporting exemplary projects around the world, and by providing a platform for dialogue, debate and exchange of ideas. In concrete terms this means providing three-month fellowships to exceptional educators, initiating and supporting best practice projects, and hosting discussions, debates, seminars and summits around the theme of creativity, informal learning and civil society.

One of the first projects of the Next Generation Foundation is to create an interactive, user-driven 'Map of Creativity'. Given the difficulties defining exactly what creativity is, it was decided to create a tool that would identify innovative projects on the basis of peer recommendation.

If someone thought a project was innovative, and served the triple objectives of creativity, learning and play, then we would put it on the Map. As of this writing, we have over 300 projects in four continents. The Map of Creativity (http://www.ngf.org.uk/map/map.html) was launched in March 2004, and projects will be evaluated on a peer review basis. New projects can put themselves 'on the map', and the Map's users will continually vet and review the quality of projects. The fundamental goal of the Map of Creativity is to make the community of educational innovators visible to itself. My experience in UNESCO, UNICEF, universities, and museums has shown amply that there is an enormous amount of innovation going on – but that the different educational 'tribes' – formal education, informal education, museums, science centers, children's museums, academic research, private research – not only don't talk to each other, they often don't even know of each other's existence. As a consequence, every day, the wheel is being re-invented. Imagine what would happen if we could take advantage of the opportunities latent in projects going on around the world.

A second consequence of making the community of learners visible is to create the possibility of coordinated action, desperately needed to combat the forces of educational conservatism, the armies of right-wing educators who insist that the only learning that matters is that which can be tested – and the earlier the better! It is against these forces, which now have the ear of many governments, that those of us who work in the field of educational innovation must work. But in order to engage effectively, we must realize that we are not alone. The Next Generation Foundation is an activist initiative, and the Map of Creativity is one small tool in the fight against the rising tide of educational fundamentalism.

It is the position of this paper that among the fundamental skills of a democratic society are creativity, flexibility, and the ability to innovate. Moreover, I believe that it is the responsibility of the community of educators to develop environments that allow the public to experience these creative forms of thought. Projects that have as their goal the communication not only of facts, but of skills, encourage new audiences – people often at the periphery of the museum culture due to the lack of confidence, background or skills. Projects that put the accent on creative skills especially encourage children, the ground in which every generation must plant the memory of its past for the future, in order that new ideas flourish. The Next Generation Foundation was founded to promote a 'creative society' and it is towards this end that its efforts will be directed.

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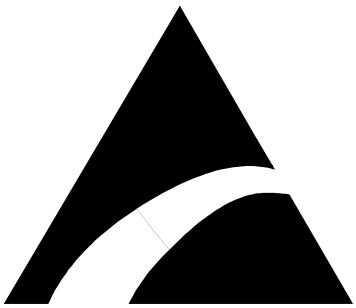

Book Review

EVERYTHING BAD IS GOOD FOR YOU: HOW TODAY'S POPULAR CULTURE IS ACTUALLY MAKING US SMARTER

Robert L. Russell

The videogame revolution has been with us for years now, but still represents a new frontier for informal learning organizations. Yet, a simple Google search of "informal learning" plus "video games" results in nearly 200,000 hits, so the topic is hardly ignored. The National Science Foundation has funded conferences and research projects on the subject. So why are millions of our youth so deeply engaged in videogaming and what is it about video games that mesmerize them?

Fortunately, there is a new book that addresses the topic: *Everything Bad is Good for You: How Today's Popular Culture is Actually Making Us Smarter*, by Steven Johnson. While there are arguments that video game activity is a useless waste of time and encourages violence, the author presents a very engaging analysis of why videogames may encourage the development of thinking and skills that receive little emphasis in schools or interactive museums. (Although Johnson's book explores the broad range of popular culture, such as changes in the nature of television program formats, in this review I will focus primarily on his analysis of video games.)

Trainers in business, industry, and warfare are increasingly using videogaming and simulations to develop the skills that are important for their workers to develop on the job. Soldiers going to Iraq may play, in effect, war videogames so they can develop essential survival skills. Likewise, the airlines have long used flight simulators to develop essential piloting skills. Many video games goes far beyond these kinds of immediate experiences and add a strong narrative or storyline to the mix.

What is it about video games and other elements of popular culture that millions find so deeply engaging? Johnson makes a strong sense that we need a good neurological model of video game users while they are engaged in the activity. He focuses largely on the brain's dopamine reward system, which keeps track of rewards and sends out alerts about whether or not the rewards are arriving. Thus, the brain motivates video game users to seek out sources of rewards in the environment. You might call that the physical manifestation of "intrinsic motivation."

Most video games provide a constant stream of explicit, although virtual, rewards. For example, *Sim City* allows users to create their own communities, but provides rewards (e.g., new activities, new elements that can be added to the environment) only until certain goals, such as population, are reached. Likewise, *Grand Theft Auto* allows users to drive around somewhat aimlessly, but provides access to new areas of the city after certain missions are completed. Initially, the virtual environments may immerse users, but eventually it is the seeking of the implicit rewards that may come next that motivates users to continue. You want to experience another part of the virtual world, you want to see what happens. While the plot lines may be simplistic and hackneyed (e.g., shooting, princess rescuing, etc.), Johnson argues that the specific content isn't so important.

Johnson takes a step back from the content of many games (e.g., *Grand Theft Auto*) and quotes John Dewey from his book *Experience and Education*, "Perhaps the greatest of all pedagogical fallacies is that a person learns only about the particular thing he is studying at the time. Collateral learning in the way of the formation of enduring attitudes, of likes and dislikes, may be and often is more important than the spelling lesson or lesson in geography or history that is learned. For these attitudes are fundamentally what count in the future." In other words, it is not what you are thinking about, it is the way you are thinking.

What is different about video games from reading books or watching movies? Here are some fundamental distinctions Johnson makes:

Video games force users to make decisions. Should you shoot or not shoot? What kind of city do you choose to build? What characteristics are you going to give the characters? Video game players have to make explicit decisions, which is not a requirement in reading or in other common activities. Johnson writes, "…learning how to think is ultimately about learning how to make the right decisions: weighing evidence, analyzing situations, consulting your long-term goals, and then deciding."

Video game users have to probe. The rules of games like Monopoly or Chess are explicit, whereas video games define some ways of getting started, but beyond that, users must "probe" and find out the rest – the implicit rules, how the game is played – by playing the game. Much of the discovery process may operate "below consciousness" and involves an intuitive process of probing, testing hypotheses, trying it again. *Pac Man* offers a very simply example. The object of this ancient game was to avoid getting eaten by monsters, then (after earning enough rewards) eating the monsters. Users discovered that the monsters roamed the environment through predictable behaviors, which were discovered through "probing," or testing.

Visitors have to "telescope." Video game users are addressing multiple, simultaneous, and nested objectives. In the second-most recent version of *Zelda*, players want to rescue their character's sister, but to do that, they must obtain legendary weapons, get pearls to get the weapons, cross the ocean to find the pearls, etc. Meanwhile, players must keep the hero alive. Players are not consciously aware of all of these objectives while involved in playing; to merely outline the objectives would take pages and pages. Johnson describes handling these multiple and multi-level objectives as "telescoping," which he distinguishes from "multi-tasking." Telescoping means staying involved and focused on the game while handling these multiple objectives and tasks, while multi-tasking is simply doing several different things at the same time (e.g., talking to friends, watching TV, shopping). In the game, if you don't stay focused, you may get killed and at least, you won't get the rewards you are seeking. Another point Johnson makes is that in the game, it is happening to you. Unlike reading a

story about someone else, you are playing the game and, in a sense, driving the narrative of the game.

Johnson continually emphasizes that it is not the content of the narratives of games like *Zelda* or *Grand Theft Auto* that engages users. Instead, it is the probing of the environment, the fast-paced and complex problem-solving nature of the games that engages the brains of the users. In brief, Johnson says it is about "finding meaning and order in the world, and making decisions that help create that order."

Not content to analyze video games, Johnson devotes a majority of his book to looking at how narrative structures of television programs have changed. He contrasts dramas and comedies form the past that may have had one simply and straightforward storyline (e.g., finding the criminal or killer in *Dragnet or Gunsmoke)* that was completed in one program to current series like the *Sopranos*, where multiple storylines progress during one episode and a story segment may refer simultaneously to several of the plotlines. In brief, watching these shows requires much more active involvement that previous dramas.

In his notes to further reading, Johnson outlines an interesting set of parameters that informal education designers and educators might consider:

Narrative structure: the storyline of the "work" involved in the activity.

Media theory: the nature of the platform of the activity.

Economics: the market environment for the activity.

Sociology: the characteristics of the audience.

Neuroscience: how the brain works, what is going on in the heads of participants.

Out of his analysis of the increasing complexity of video games, television dramas, the Internet, and television reality programming, Johnson tries to make the case that this may have contributed to raising the average "IQ" of Americans during the past several decades. He calls this the "Sleeper Curve." He makes a strong case that mass culture has does result in real cognitive benefits and gains and that movie goers, television watchers, and gamers are developing intellectually and learning, even if the focus is *Grand Theft Auto* or *Survivor.*

Informal educators cannot afford to ignore the nature of contemporary mass culture and to take advantage about what it is about new forms of media and gaming that so engages participants. It is only with a more explicit analysis and understanding of these new forms of media that exhibit designers and program developers can incorporate useful elements of these media into the experiences they design for informal learners.

There is a growing wealth of research and other literature on video gaming. A good place to start is an electronic journal like *Game Studies* (http://gamestudies.org). I would also encourage readers to take another look at John Dewey's classic, *Experience and Education*, which has been the focus of a number of articles by Ted Ansbacher and me in the *Informal Learning Review.*

Johnson, Steven, *Everything Bad is Good for You: How Today's Popular Culture is Actually Making Us Smarter* Riverhead Press, New York, New York. 2005, 256 pp. $23.95 hardcover, $14.00 paper

Robert L. Russell is Science Advisor of the Self-Reliance Foundation. He also consults on the design and evaluation of exhibits and other informal learning media. Russell can be reached at hanarus@aol.com.

30TH ANNUAL EXPLORATORIUM AWARDS

On April 4, 2007, the Exploratorium hosted the 30th Annual Awards Dinner. Carol Bartz, Executive Chairman of the Board at Autodesk was presented with the prestigious Director's Award; Natalie Angier, Pulitzer Prize-winning journalist for the *New York Times*, received the Public Understanding of Science Award; and Dr. Kenneth Miller and Dr. Eugenie C. Scott, scientists both active in the evolution vs. intelligent design debate, received the Outstanding Educator's Award. The Exploratorium has honored leaders in technology, science and education for over a quarter century.

The Awards Dinner Event Committee includes, among others, President and CEO of Autodesk Carl Bass; Daryl Austen, Chairman and CEO of Cisco; John Chambers, Chairman Emeritus of Intel Corporation; Gordon and Betty Moore, Chairman of NetApp Don Valentine and Rachel Valentine; and CEO of NetApp Dan Warmenhoven and Charmaine Warmenhoven.

Funds generously provided through the Exploratorium Awards Dinner are used to develop and maintain the 400+ educational exhibits that are the heart of educational programming for training teachers in the Greater Bay Area, as well as in 862 school districts in 39 states. The funds also enable the Exploratorium to reach out to underserved audiences in the community, and to make science content easily understandable and freely available to the 20 million annual visitors to our Website.

The Exploratorium honored Carol Bartz for her work in revolutionizing design software and for her commitment to encouraging young women and girls in math and science. Ms. Bartz is the executive chairman of the board of Autodesk, Inc. She held the position of chairman, president and CEO of Autodesk for 14 years, stepping down in April, 2006. Autodesk revolutionized the design world with its AutoCAD (computer-aided design) program used to assist engineers, archi-

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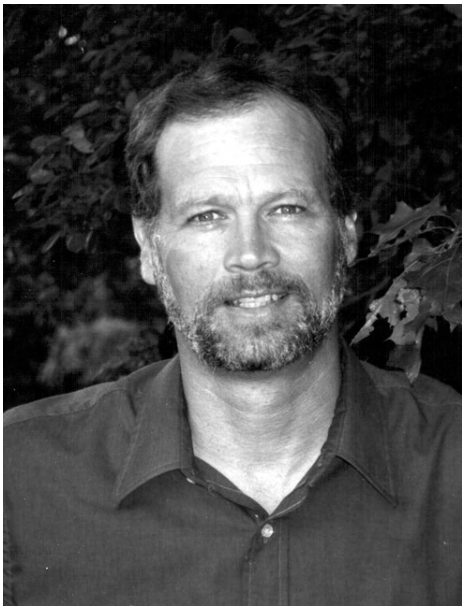
tects and other design professionals in their work, eventually including designers in the manufacturing and infrastructure fields. Their numerous software programs are used all over the world by designers in the building, infrastructure, manufacturing, media and entertainment fields, including even the exhibit designers at the Exploratorium. A leader in the technology field for over 20 years, Ms. Bartz has been recognized by numerous organizations and publications including *Fortune, Wall Street Journal, Barron's,* and *Forbes*.

Pulitzer Prize-winning journalist Natalie Angier was honored for her passionate and successful life writing about science. Currently a science writer for *The New York Times*, Ms. Angier has also contributed to over 25 magazines including *Discover* and *Time*. An accomplished author, Ms. Angier has published three books, including the critically acclaimed *Woman: An Intimate Geography*. Her 4th book, *The Canon: A Whirligig Tour of the Beautiful Basics of Science* is slated for release in May 2007.

Brown University Biology Professor, Dr. Kenneth Miller, is an expert in cell membrane structure and function. A prolific writer, Dr. Miller is the author of more than 50 scientific papers and reviews. He also coauthored three different high school and college biology textbooks that are used by millions of students nationwide. Dr. Miller is the author of *Finding Darwin's God: A Scientist's Search for Common Ground between God and Evolution* and served as a key witness for the plaintiffs in the Dover, Pennsylvania intelligent design case. He has received numerous honors including 5 teaching awards and the President's Citation Award for Distinguished Contributions to Biology Sciences.

Dr. Eugenie C. Scott is Executive Director of the National Center for Science Education, Inc., a not-for-profit membership organization of scientists, teachers, and others that works to improve the teaching of evolution, and of science as a way of knowing. One of the country's foremost experts on evolution and intelligent design, Dr. Scott has leant her expertise to numerous organizations, foundations, school boards and academies including the ACLU and the National Science Foundation. She has received numerous honors including the Bruce Alberts Award of the American Society for Cell Biology and the Isaac Asimov Science Award from the American Humanist Association. She has held elective offices in the American Anthropological Association and the American Association for the Advancement of Science.

From an Exploratorium press release



Dr. Kenneth Miller

Dr. Eugenie C. Scott

DEFINING AND MEASURING VISITOR EXPERIENCE

Sylvia Matiko

"Visitor Experience" seems to be something that many organizations struggle to define and measure. Ask people for their definition of visitor experience and you'll get a variety of answers. How would you define visitor experience? Typical definitions usually include how visitors enjoyed their visit – was it good or bad?

For many of us, the easy part is recounting in detail when an experience is poor. But it becomes more difficult when two people may have an entirely different experience in the same environment or situation. So what can make one person rate an experience poor while another rates it great? How can you possibly define and address this?

We would suggest that visitor experience can actually be broken down into thousands of elements but has three major components that make up the experience: the Audience, the Physical Assets, and the Interactions.

"The audience" takes into consideration many facets such as age and other demographics such as educational level, occupation, household income, etc. Couple that with the psycho-demographics such as beliefs and values, the country that they grew up in, personal likes and dislikes, learning styles, and you can see how complicated just this one component can get.

"The physical assets" deals with the visitor's experience in and around your facility. Is there too much reading or programming content? Are the exhibits appropriate for the target audience? Are there enough parking spaces and bathrooms and are they clean and safe? Is there appropriate theming, too many sound effects, not enough for an 8-year old to do? Are there enough amenities, are they situated in the right places? Is the carpet clean? Do the exhibits resonate with the audience? The list can go on.

"The interactions" component deals with how your visitors interact with your staff,

exhibits, volunteers, website, etc. Are your volunteers positioned correctly? Are your staff visitor-friendly or surly?

You can see how quickly these elements add up to make an extremely complex situation.

Each of these components can be measured using various tools such as exit surveys, tracking studies, formative and summative evaluation of exhibits or focus groups. These tools can certainly help but what is needed is a more sophisticated, holistic analysis.

Then the bigger question comes to light: Why bother measuring visitor experience at all? Why is this important? The resounding answer we got from everyone we spoke to was that understanding what visitors want and designing an experience for them leads to outstanding visitor experience and therefore sustainability. The non-profit attraction can then live up to its mission and the for-profit attraction can improve its bottom line.

So if we can agree that visitor experience is worth measuring, how can we possibly measure it accurately when there are so many facets to it? In addition, is there something that can be used before the project gets built which will shape the visitor experience before design plans start being executed, preventing costly mistakes and disappointing outcomes?

Experience DNA comes as close to answering these questions as possible. Experience DNA has been used by over 70 attractions worldwide. It has recently been introduced into North America but has already had resounding success with such world class organizations as the Natural History Museum in London, Two Oceans Aquarium in South Africa, Bristol Zoo in the UK, the Manchester Museum of Science & Industry and most recently Dubailand. The first North American organization to use this service was the National Aquarium in Baltimore.

What is it? Experience DNA, according to its clients, is the world's most comprehensive visitor experience model, which delves into every level of visitor experience pinpointing exactly what works and what doesn't. Developed in the United Kingdom by a company called Vision XS, their team of mathematicians, psychologists, statisticians, and market researchers scientifically identified key issues in visitor experience in over 19 countries around the world. For example, they know how long an 8 year old can tolerate standing in line versus a 40 year old and which country has the least tolerance for queuing. They know what psychological elements are necessary for visitor enjoyment by age group and country. They understand what a 4 year old loves and hates compared to a 17 year old.

Experience DNA is not just another poll or exit survey. It is a comprehensive and complicated process. First, each country was analyzed and data collected about the general psychological profile of its citizens. (The US data was collected within the last 6 months.) Next, this experiential information was fed into a giant database. The team of researchers can then to go into any attraction and break it down into a variety of different components and psychological elements. These results are then compared to the national data. Experience DNA reports how an attraction performs in relation to what visitors really want in a particular country by 8 different age groups.

Experience DNA takes into consideration not only the psychological appeal of the attraction, but also other issues which impact visitor enjoyment. Are there enough amenities? Are they located in the right places? What is the capacity of each exhibit, and can everyone see it? How does a bottleneck affect visitor enjoyment? What journey is the visitor taken on? Does the attraction have too much reading and not enough creative play? Is pricing in line with the experience visitors are receiving? Are revenue opportunities being missed that visitors would actually enjoy? Are visitors receiving too much experience or not enough? What's the overall quality of the experience and where does it fall short? What's the age suitability of the exhibits?

There are 8 parameters of Experience DNA:

- Visitor Flow
- Visitor Journey
- Experience Quantity
- Experience Quality
- Learning Style
- Psychological appeal
- Price Value
- Capacity

Visitor Flow identifies how the visitor moves around an attraction, how long they stand in lines, how long they spend looking at something, how much time they spend walking.

Visitor Journey takes a look at the psychological journey visitors are taken on. Are there too many things that over stimulate them or not enough things for them to engage in? Is their experience too linear (looking at exhibits over and over again)? Does the journey have enough peaks and vallies as they walk through? Are parents bored? Is there enough staff interaction?

Experience Quantity looks at how many experiences per hour the attraction offers compared with how many the visitor actually needs. Everyone knows that a 7-year old needs more activity than someone aged 50 but how much experience should each get?

Experience Quality looks at the actual quality of experience the visitor receives. We find the chart on the following page to be really helpful. It indicates which psychological elements need to increase or decrease. So for example in the chart below, which happens to be a zoo, the contact with animals needs to increase for 3 – 10 years olds and also for 17 – 66 years old. This example also shows us that there is too much "hearing" and "entertainment you look at".

Learning Style assesses how the visitor rates the experience and is becoming a predominant ingredient in determining the quality of an experience. Each visitor learns using a combination of four different learning styles, often having a preferred dominant style. Experience DNA identifies which of the four learning styles is predominant and perhaps which ones need to be balanced out.

Psychological or Market Appeal assesses which components in an attraction are the most psychologically appealing. This is done by rating the elements according to their relative popularity. So it can, for example, tell you which displays and exhibits are the most appealing for each age group.

See "Experience," continued on following page

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Price Value will calculate what the experience value is and compares it to current pricing. It can then also determine what elements may need to be added to bring the experience value into line with the price charged.

Capacity deals with bottlenecks, price per square foot, and, in terms of investment, capacity per hour and compares it to similar attractions.

As you can see Experience DNA provides a comprehensive service but the "rubber meets the road" when we interview people who have used it. It is also better understood when applied to various practical situations.

Ice Station Antarctica, Natural History Museum in London

The Natural History Museum (NHM) was one of the first museums to use this tool to help them model the experience visitors would get for a planned temporary exhibition called "Ice Station Antarctica." It was a temporary exhibition to be repeated in up to 20 different countries for the family market. The NHM wanted to make sure that any such exhibition had a positive resonance for the family market.

The NHM were aware that the concept of Antarctica is a bit nebulous and unless you have a more adult understanding of what Antarctica is all about – its size, impacts etc., then it will be a difficult sell to the younger audience.

The NHM in-house exhibition staff compiled a "wish list" of everything that they felt they wanted to include in this exhibition and came up with a design concept of zones, flows and contents. It fit within a theoretically infinite space.

This outline design was provided to Vision XS (the creators of Experience DNA) and NHM asked for the concept to be run against three models:

- The UK market
- The Polish market
- The US market

Vision XS reported back on each of the three models and presented their findings that included both detailed statistical evidence – graphs and narrative – and most usefully a "one liner" suggestion that stemmed from the analysis of each topic.

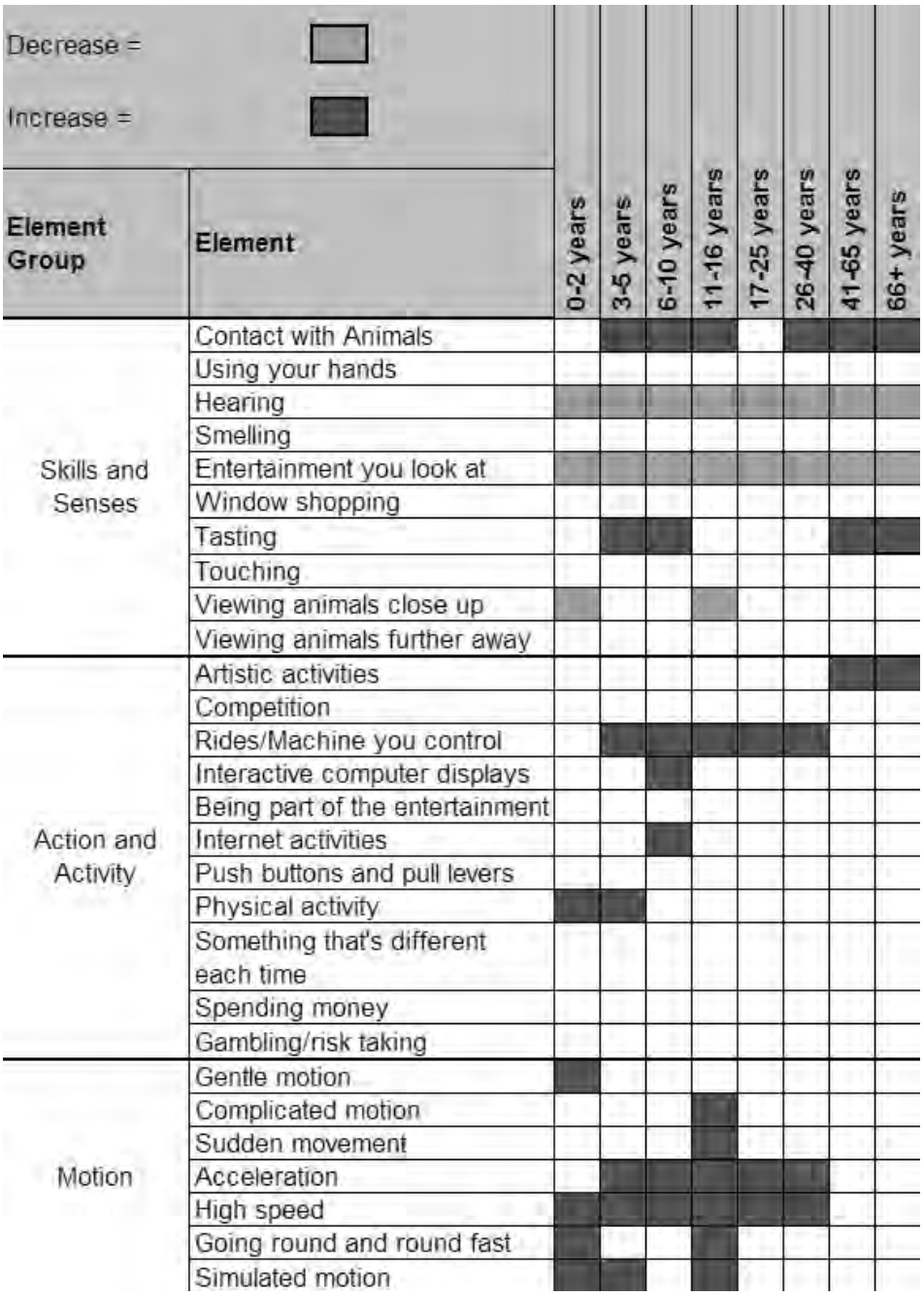
Amongst other things the outcomes showed that their proposed product exceeded visitor expectations in the Polish market, was about right for the UK market, and was below visitor expectations for the US Market.

This helped inform the Natural History Museum as to which markets were appropriate for the exhibition.

The report back from Vision XS provided extremely useful guidance on the optimum layout and content for the exhibition itself; it informed:

- The need to have high interactivity zones and low interactivity zones [the initial thinking had been to have very full content one zone after another]. Visitors need to have the chance to 'graze' and not be assailed with high volume content throughout the experience. The 'pacing' of an exhibition needs to be right to ensure enjoyment.

- There were recommendations on which zones should be kept high activity and rich and which zones should have a slower pace. Changes were made in the thinking and planning to absorb



this recommendation. Content was reorganized so that the exhibition delivers a consistent level of interactivity for all visitors.

- There was feedback about the quality of the experience to varying age profiles of visitors which enabled the Museum's interpretation team to maximize the potential of each zone and balance learning objectives, interactivity, and atmosphere.

- There was feedback about some problems in terms of dwell times/pinch points and overly complex areas. This led to changes in the design to remove these and make the visitor flow more effective.

- There was feedback on the value for money – a matrix of entrance fees charged against concomitant visitor expectations. This confirmed the Museum's primary objective to provide a rich and engaging experience for a family audience.

The report itself has enabled the exhibition staff to not only amend their practical plans but has also provided a very useful statistical basis to engage and motivate the internal steering committee, and to link that data to the resource arguments within the Museum to finance the overall activity.

The staff found the process easy and useful and Ice Station Antarctica opened on May 25th. It will be on display at the Natural History Museum until April 2008. It then leaves on its world tour including countries in Europe and Asia.

Experience DNA also has the ability to provide scientific evidence of need which can be helpful in fundraising efforts. The Manchester Museum of Science and Industry used the Experience DNA report to help support their $25M grant application.

Woburn Safari Park in the UK used Experience DNA to model their existing attraction to see where it fell short and what the price vs. value proposition should be.

The National Aquarium in Baltimore used Experience DNA to better understand how to engage their visitors and what psychological drivers needed to be enhanced or taken away.

The list goes on but what Experience DNA does not do is try to evaluate content and learning outcomes of exhibits. This is an area of evaluation that Science Centres and Museums have used effectively for a long time. However, Experience DNA can help designers better understand how their designs play out in the minds of the visitor and what overall experience they will have before design plans get built.

This is certainly one of the most comprehensive tools we've come across to measure overall visitor experience and one that is built on science, not just gut feeling. To learn more about this visit www.experiencedna.com.

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LOOKING AT BONES - DO CHILDREN 'SEE' MEANING?

Sue Dale Tunncliffe and Angela LaGrange Scott

Abstract

What do children notice when they do to have a focused task and look at animal skeletons as exhibits? We know that their spontaneous conversations at museum animals focus on the salient features of anatomy and the behavior displayed by the pose of the specimens as well as naming the animal to their satisfaction. There is little work that refers to their observations and interpretation of skeletons.

Primary aged children were interviewed at four different skeleton exhibitions in a natural history museum. Spontaneous conversations were so few that an interview questionnaire was designed. The answers were analyzed according to a modified systemic network worked out from reading and re-reading of the transcripts.

The data reveal that children clothe the animals in their mind and talk about the skeleton as if it were a whole animal. They have few powers of observation and fail, either spontaneously or with prompting, to relate structure to function. Furthermore, the data reveal that home and school are acknowledged as sources of information, depending on the species. "Text echoing" of the standard statements about functions of the skeleton which teachers use are heard in responses of older primary and secondary pupils.

Introduction

There are few museums which are dedicated to skeletal exhibits. The Grant Museum of Zoology at University College London is one. However, many natural history museums do have galleries of skeletons (e.g. The Natural History Museum, London) or some skeletons and bones in their other galleries. We know that visitors to museum looking at taxidermically preserved animal specimens name the animal in nearly all conversations. Comments about obvious physical features such as shape, size, scars, horns, hooves and so on and comments about the behavior of the animal shown by the pose in which the animal is displayed in occurred over a third of conversations (Tunnicliffe, 1995).

Few studies have looked at people's understanding of what is inside animals—skeletons and other organ systems. This is surprising because of the central significance of the endoskeleton for the chordates and the inclusion of the skeleton in many science curricula and the exhibition of skeletons in many museums. The few studies about internal anatomy of vertebrates have investigated pupils' knowledge about animal skeletons (Tunnicliffe & Reiss, 1999) or the structure of animal organ systems (Driver *et al.*, 1994; Reiss and Tunnicliffe, 2001). Most in-depth work has been done only on human bodies (Gellert, 1962; Williams, Weston & Moon, 1989; Osborne, Wadsworth & Black, 1992; Cox, 1997; Teixeira, 1998), or on human skeletons only (Guichard, 1995). Much of the research about skeletons or organs has been in the form of interviews or has used drawings in some way and has occurred in the classroom. Tunnicliffe and

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Yonally (1999) inquired whether skeletons had a role in live animal collections in zoos and considered that they complement the live animals, often being "clothed" by the visitors.

Young learners selectively give value to new sensory information (Osborne and Wittrock, 1983) so the generative learning process arising from observation is not silent but hugely assisted in by the nature and construction of language. Science educators and teachers tussle with this process of writing and talking about what was observed (Millar and Driver, 1987; Woolough, 1994, Laws 1996).

Observation is a fundamental cognitive ability (Millar, 1994) and is enshrined (in some countries including the United Kingdom) within the contemporary idea of Key skills (DEE, 1995). Although observations underline the scientific process, it is not just a matter of looking—it clearly precedes the formation of ideas about what to investigate (Tomkins and Tunnicliffe, 2000). Millar (1994) argues that observation is not a process unique to the methods of science but just one of the approaches that people take from time to time to make sense of the world. It is a skill that will not be improved by any practice that considers it as separate from the mental processes that go with it. Just looking at something does not mean useful observation is occurring.

Diplodocus skeleton at the Natural History Museum, London

Methodology

We made initial observations at various skeleton exhibits within the Natural History Museum, London. We observed at a python skeleton (in a special exhibition), the brachiating gibbons on the upper level, a whale skeleton in the mammal hall, and the dinosaur in the entrance hall. We observed both primary school pupils and family groups.

We found that visitors rarely made any comment about skeletons. Thus, we decided that we would have to interview rather than record spontaneous comments (Tunnicliffe, 1995). An interview questionnaire was drawn up as follows.

QUESTIONS AT SKELETONS		
Type of skeleton		
Museum	Date	Family or School Group
Age	Name	Sex
What is this?		
How do you recognize it (skeleton) as that? (What made you know it is a....?)		
Where did you learn about it?		
What is it for?		
If they respond 'for learning' or 'to look at' ask 'What does it do for the animal?'		
Can you guess where this animal lives? What is the environment where it can live? What helped you decide?		

The questionnaire responses were analyzed using a systemic network approach. This was based on the categories that formed the responses within the topics of the questions asked. The network is based on those used in a study of the conversations of children's zoos, museums, and a farm by Tunnicliffe (1995) from where fuller details may be obtained.

Essentially, the elements of a conversational exchange are allocated to a category that has been given a number within the coding network. The incidence of each category was entered into a database and the totals were found. The network concept is like that of Russian dolls, each subordinate category fitting inside a larger one. At one extreme of the continuum along which the conversations were categorized are highly specific items; while at the other end is the main descriptor, in this case "group's comments." The final network required 50 terminals to describe all the children's conversational content. The numbers at the right of Figure 1 label the most specific level of table categorization, the smallest categories as it were. A bar, "[," indicates that an attribute may be either/or but not a member of both categories, while a bracket, "{," indicates one of a number of categories which the response about the skeleton may be allocated. Further information about systemic networks used in this way may be found in Tunnicliffe, 1995.

In the analysis process, the text on the questionnaire was marked with the appropriate number of the terminal for each topic mentioned, the number taken from the network. Thus, if the respondent mentioned the name of the animal, that reference to the name would be scored as a response in category 5. However, if the respondent said it was 'the skeleton' of the animal, it would be counted in category 7. In a similar manner, if the respondent replied that they had learned about skeletons at school, the response was counted in category 14 within the superordinate category of source of information. The total score of all the responses were tallied.

Results

Interviews were conducted with 261 primary aged children, 147 of whom were visiting with their school and 114 with their families. Key stage one is the age group 5 to 7 years in English primary schools and Key stage two is 8 to 11 years when they move on to secondary school.

School Children

147 interviews with primary school chil-

dren (with an accompanying adult who did not respond) were conducted. Forty-four were at the whale, thirty at the dinosaur, twenty-four at the gibbons, and forty-nine at the python. Fewer visitors went upstairs to where the gibbon skeletons were displayed and fewer stayed in the entrance hall.

Most children referred to the criteria they used for identifying the skeleton and few mentioned the label. Over three quarters of the replies referred to using salient features of the skeletons of which length was referred to in about half of the responses except for those about the gibbon where no reference to length was made. Significantly more references to the shape of the skeleton were made with reference to the dinosaur. Significantly more children referred to other features with respect to the primate than they did to any other animal skeleton.

Sources of learning were referred to similarly overall but significantly more referred to home as their source at the dinosaur skeleton (63%) than at the whale (45%). In the subcategory of "home," the media were referred to with respect to whales and dinosaurs. School was mentioned as a source of knowledge significantly most often with reference to the primate. The museum or a zoo were mentioned significantly more for knowledge about the whale.

The function of the skeleton was mentioned less for the skeleton of the dinosaurs than for the whale and the primate. Significantly more children said that the function was for other people to see. Yet more children responded that the python skeleton was for people to learn from. Significantly fewer responses replied that the skeleton had a function for the animal itself for the whale than the other three skeletons. The role of the skeleton as a support function was heard least for the whale. No other categories were significant and movement was cited as the next most frequent function. Sometimes what appeared to be "text echoing" or remembered "teacher talk" was heard. For example, a year 4 (8 years old) girl replied "the skeleton is to support and to produce red blood cells" whereas year 9 pupils (14 years old) provided slightly more information telling us for example, that "skeletons provided attachment for muscles."

Responses related to the environment, which is what we were particularly interested in, were disappointing. Significant differences occurred in the responses to the location where the animal had lived and the dinosaur was the lowest (33%). One boy replied "It must have lived in a very hot place because its bones are burnt" reflecting the concept that dinosaurs as a living entity were in skeletal form. When the children were asked for clues that helped them realize in which locations the animal had lived, none were received for the python. Comments were passed regarding its physical form and its imagined behavior. Pre-knowledge of the animal was cited significantly more for the whale (39%), the dinosaur (20%), and the python (28%). Other clues, such as its similarity to humans, were mentioned particularly for the gibbon.

Family Groups

One hundred and fourteen interviews were conducted with primary aged children in family groups visiting as a leisure excursion.

Significantly fewer of the families identified the gibbon by its name but referred to it as a gibbon's skeleton. No families called the dinosaur skeleton such but referred to it as a dinosaur. Significantly more families referred to the shape of the dinosaur than they did to that of the other skeletons and most comments about other aspects of the skeletons were made at the gibbons where comments reflected on the position of the arms and the resemblance to the human skeleton.

Similar sources of knowledge were cited for all skeletons, of which "school" was cited most with regard to whales and the primates, while "home" was cited for the dinosaur. "The media" was referred to significantly less than "home" with regard to the whale as the remembered source of information. The museum, and occasionally a zoo, were mentioned as the source of information significantly more for the whale and "Just know" was mentioned for the python. Functions of the skeleton being "for other people" were mentioned significantly more for the dinosaur and the role of the skeleton in support mentioned least for the python ($p>0.005$).

Questions about the environment revealed significantly less comments for the python and the correct location, e.g. "Sea," was given for the whale significantly more for the whale and the gibbons. The most incorrect locations were cited for the dinosaur. Respondents replied significantly less about the clues in the skeleton that were picked up by the children for the python but the whales' skeleton provided significantly more clues to its habitat than do the other skeletons.

Analysis of responses from interviews with children from primary school groups and families

Table 1: Identify of exhibit and criteria for giving that name

All data n = 261	Family n = 114		Schools n = 147		Chi squares	Probability
Topic		%		%		
IDENTITY	114	100	147	100		
animal	71	62	94	64	N/A	
skeleton	18	16	25	17	0.007	
animal skeleton	23	20	31	21	0.14	
CRITERIA	114	100	144	98	1.59	
label	13	11	13	9	2.35	
salient anatomy	98	86	119	81	0.47	
length	32	28	56	38	1.151	
shape	58	51	42	29	2.89	
other	62	54	76	52	13.51	p>0.005
just know	1	1	9	6	0.196	
other	25	22	23	16	4.79	p>0.05

See "Bones," continued on following page

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Table 2: The source of their knowledge about the skeleton

All data n = 261	Family n = 114		Schools n = 147		Chi squares	Probability
SOURCE	105	92	143	97	3.63	
home	45	40	57	39	0.013	
books	14	12	27	18	1.80	
told	10	9	15	10	0.15	
media	17	15	17	10	0.64	
school	54	47	48	33	5.84	p>0.025
books	9	8	12	8	0.01	
were told	4	4	3	2	0.53	
media	6	5	1	1	5.17	p>0.025
museum/zoo	12	11	22	15	1.12	
other	5	4	4	3	0.53	
just know	8	7	7	5	55.92	p>0.005

Table 3: The function of the skeletons

All data n = 261	Family n = 114		Schools n = 147		Chi squares	Probability
FUNCTION	108	95	129	88	3.75	
other people	18	16	19	13	0.43	
learn	6	5	12	8	0.52	
other	9	8	12	8	0.01	
for animal	109	96	129	88	4.94	p>0.05
shape/support	79	69	85	58	3.62	
movement	22	19	33	23	0.38	
prey	2	2	5	3	0.67	
protection	5	4	10	7	0.69	
behavior	1	1	1	1	N/A	
other	7	6	13	9	0.66	

Table 4: The environment where the children thought the animal lived

All data n = 261	Family n = 114		Schools n = 147		Chi squares	Probability
ENVIRONMENT	109	96	124	95	0.77	
location	108	96	121	95	0.04	
correct location	96	86	86	68	85.84	p>0.01
incorrect	8	7	42	33	24.79	p>0.005
CLUES	103	90	101	80	5.41	p>0.025
physical	67	60	76	60	0.03	
behavior	45	40	17	13	21.63	p>0.005
pre-knowledge	10	9	34	23	13.04	p>0.005
other	25	22	21	17	1.13	

When the data from the interviews of school and family children are compared, they reveal that both family and school children named the animal (60%) rather than describe the exhibits as the skeleton of an animal. When two percentages are given in these data, the first figure refers to the responses of school children and the second to those of children with their family. The school children mentioned other criteria for naming the animals significantly more than did family children yet family children mentioned other sources of knowledge significantly more (Table 1). Those respondents mentioning the skeleton specifically as a skeleton were just under 20%. 20% called it the skeleton of that particular animal. The salient features of the skeleton were mentioned by over 80% of both groups. "Home" was the place mentioned as their source of knowledge more often than schools even for pupils interviewed on a school visit. However, the only significant difference in this group of answers (Table 2) was that family children mentioned school and the media as a source of knowledge. Over 90% (92% and 97% respectively) referred to their source of knowledge about skeletons, which was home 40% and 39% respectively by the school and family groups. The source of knowledge indicated in approximately equal amounts were books 12% / 18%, media 15% / 16%, and being told (9 and 10%). School was mentioned as the source of information (47% and 33%). Both groups mentioned books in 8% of replies, which was the single highest specified source of information irrespective of location. Museums and zoos were mentioned relatively little (11% and 15%, respectively).

Almost all interviewees mentioned a function for the skeletons. However, 16 % and 13% said that the function of the skeletons was as an exhibit for other people to see (Table 3), indicating that the question should have been formed more succinctly. Yet we did not wish to cue the children by using the word 'skeleton' in the interviews. More family children said that the skeleton was for the animal than did school children although both responses were high in number. About 69 % of family children stated that the skeleton was for supporting the animal. 19% and 23 % of the respondents referred to movement as a function for the skeleton, other functions such as protection were scarcely mentioned. None of these categories were significantly different between family and school children

When asked if the skeleton provided any clues to where the animal lived when alive (Table 4), significantly more ($p>0.01$) family children gave a correct response although this was after some cuing (86%, 68%). More school children gave incorrect answers ($P>0.005$) than did family children. Why this should be so is the cause for some speculation. Moreover, significantly more family children ($p>0.025$) 90% and 80% said what clue the skeleton provided in working out where the animal had lived. Sixty percent in each group referred to a physical clue such as the brachiating position of the

gibbons indicating that they live in trees or paddle like limbs of the whale indicating that they lived in water.

Family groups mentioned the shape of the skeleton significantly more than did the schools as one of the criteria issued in identifying the type of animal from which the skeleton came but more school groups said that they "just knew." Family groups surprisingly mentioned school as a source of information significantly more than did the school groups and mentioned media more. Again, significantly more responses from families mentioned the skeleton's functions being for the animal and gave the correct habitat location and significantly more school children gave incorrect locations. More families mentioned the clues they used in identifying the animal habitat with families mentioning known behavior significantly more ($p>0.005$) more but schools mentioning previous knowledge about the animal significantly more ($p>0.005$).

Discussion

The majority of children "clothed" the animals when looking at the skeleton and the majority did not refer to the skeleton as a part of the animal. The dinosaur skeleton was an exception. Children apparently considered that the skeletal structure is the dinosaur and that is how it existed. One boy said that the dinosaur "Must have lived in hot places because his bones were burnt brown."

The role of skeletons in the working of an animal seems scantily understood. The function of the skeletal vertebrate organization in both movement and support of the animal was mentioned surprisingly infrequently. Furthermore the children's understandings of form and function related to habitat was rudimentary and we obtained responses only after simplifying the questions to "Did this animal live in the air, on land, or in the water?" for the skeletons other than those of the gibbons. Thus the way in which the skeleton is positioned and arranged can provide vivid clues to the visitors but a conventional display posture does not.

The conventionally posed skeletons do not tell a readable story unless the observer has been trained to look for particular clues in the skeleton, which can provide them with information. The skills of observing with meaning need to be taught in school from the earliest years. Skeletons need to be taught as functional units, not as an anatomical exercise. While school is a source of information about skeletons, home seems to be recalled as of more importance. Why should the school children give more incorrect responses regarding the natural environment of the animals (Table 4)? We can only speculate that when on a school visit they felt they must give an answer even if they were unsure of the veracity of it. Hence, combined with the above comments, there are implications for teachers.

Implications for Teachers and Museums

Skeletons, especially those of dinosaurs, are a popular museum exhibit for children. However, these data presented in this paper indicate that the children, pupils or leisure visitors, do not always understand skeletons in museums as part of a once living animal and that the form and function of a skeleton as biological evidence are not appreciated. Teachers need to ensure that their pupils do understand the role of the skeleton and how it is adapted to the way of life of the animal. They should have practice before a museum visit at reading clues through both form and function.

Furthermore pupils need to be aware of the basic vertebrate plan for skeletons, including the quadruped limb and the vertebral columns with the skull at the leading end. It is salutary that home is the source of information mentioned most and that in this work the media is cited as used more at home than at school. However, this may reflect the varied socio-economic groups who paid to visit the museum because at the time this work was undertaken there was an entrance charge for the museum. This need for a payment does preclude some children from certain backgrounds from visiting and schools from organizing such visits.

Museums need to be aware of the way in which children respond to the skeletons and pay attention to the resources they provide for schools and families to work with skeleton exhibits. An explanation of the role of the skeleton and from where they are obtained as an advanced organizer to skeletal exhibits would be useful learning resource for visitors.

The majority of children "clothed" the animals when looking at the skeleton and the majority did not refer to the skeleton as a part of the animal. While a popular type of exhibit, this category of visitors revealed only basic knowledge of skeletons with a rudimentary understanding of form and functions. Even in exhibits which are interactive, with explanatory diagrams of form related to function, visitors acquire little increase in their zoological knowledge (Tunnicliffe and Laterveer, 2002). So it is not surprising that, just using their own knowledge with which they come to an exhibit about skeletons, they interpret that which they see at a very basic everyday level, with overtones of work learned in school.

The study of vertebrate skeletons can enhance the observational and hypothesis skills of the viewers. With school children, this is an important part of inquiry science. Once an hypothesis is postulated, the students can be challenged to research answers through a variety of media. Skeletal observations can assist students in grasping the role of the skeleton in movement, and hence neural behaviors of the animal when it was alive, as well as developing a clearer undertaking of the anatomy as the skeletal structures relate to soft tissue. Although the children interviewed were poor at analyzing and 'reading' a skeleton, with assistance from teachers and museum educators they could work out and learn further about adaptation to the environment of the animals. Furthermore, the study of skeletons leads to other scientific studies, particularly physics, where, for instance, the role of parts of the skeleton as levers, forces and stability, cantilevers and arches can be studied. Moreover, linking science with the self creates an understanding of form and function of the skeleton of an animal and can contribute to the understanding of first aid management of accidents, particularly of fractures in humans. Hence, studying skeletons and helping students view them with meaning can contribute, not only to the science educating of students, but also can contribute to the development of an awareness of citizenship in the students.

See "Bones," continued on following page

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PUBLIC UNDERSTANDING OF SOME EARTH SCIENCE CONCEPTS RELATED TO CLIMATE CHANGE

Robert L. Russell

In an article in the previous issue of the *ILR*, I discussed several studies of the public's understanding of the science underlying climate change. Plate tectonics and geological time (sometimes called "deep time") are also important concepts for the public to understand to have a full appreciation of one important influence on climate change (i.e., the location of earth's land masses). It is also important for the general public to have an appreciation of the time scales that have been involved in climate changes in the earth's past, so that current climate change can be understood in context. This article presents brief overviews of some studies of public understanding of plate tectonics and of geological time.

Plate tectonics

A major factor in the presence of polar ice caps on Earth is the location of the continents. As plate tectonics steer landmasses toward the poles, ice forms easily and ice ages are more prevalent. As the continents mass toward the equator, ice cannot form as easily. The uplift of the Himalayas and the Tibetan plateau caused major changes in global circulation patterns leading to the current cool period.

In a small-scale front-end study done for a museum exhibition, Borun (1995) found that museum visitors were familiar with natural phenomena such as earthquakes but knew little about the causal factors. A number of studies show that many teachers have naïve or alternative conceptions of various earth science concepts. For example, Dahl et. al. (2002) found that, in general, "teachers lack adequate subject matter knowledge for teaching geoscience concepts," as exemplified by their inadequate understanding of concepts regarding the composition and interior of the earth. Kusnick (2002) found preservice teachers to lack a good understanding of rock formation, even after they had taken a college-level

course in earth science. There are also numerous studies of children's naïve understanding of various earth science concepts (e.g., Agan and Sneider, 2004; Lightman and Sadler, 1988).

It should be noted that plate tectonics has only recently matured as an area of research and was not a significant part of K-12 science curriculum until recently. Plate tectonics is now an important element in the National Academy of Sciences K-12 National Science Standards. Organizations such as the American Geophysical Union have also developed various efforts, such as Earth Week, to educate the general public about geosciences.

Geological time

We generally understand time on a human scale and in terms of our everyday experiences – seconds, days, decades, recent history. There is generally a break between this relatively intuitive understanding of time and understanding what some call "deep time," that is, looking at geological events for the past 4.6 billion years. Natural history museums have long had difficulties in presenting geological time scales in exhibits on dinosaurs or other geological topics.

According to Dodick (2003), no systematic studies have been carried out concerning students' understanding of deep time. However, Trend (2001) cites other studies to support the view that students and teachers are familiar with a relatively small number of geological events and that they categorize these events in two or three broad eras, such as "extremely ancient" and "less ancient." He found that seventeen year-old British students demonstrated some fundamental misconceptions of geological time: they confused the Big Bang with asteroid impacts; they conflated the recent Ice Age with general climatic cooling; and they connected dinosaur extinction with the Ice Age. Likewise, in its periodic survey of science literacy, the National Science Foundation (2002) found that only about half of Americans answered correctly (true) "The earliest humans did not live at the same time as dinosaurs." Trend (2002) points out that understanding of deep time is not only relevant for understanding geoscience, but also geography and environmental science. For example, understanding the dramatic changes in the earth's atmosphere since the beginning are fundamental to understanding how life began and how life interacted with other earth systems to change the proportion of oxygen in earth's atmosphere.

Conclusions

Museum exhibitions should continue to introduce plate tectonics to the general public and explain why it is an important factor in understanding the radical climate changes that have occurred in the earth's past and how they are different from current warming due to human activities. Likewise, it is important for the public to understand the scale of geological time so that past climate changes are understood in context.

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PRESIDENTIAL LIBRARY/MUSEUM ATTENDANCE

The National Archives spends almost $100 million each year maintaining presidential libraries for former commanders-in-chief from Herbert Hoover to Bill Clinton. The Nixon, whose Library was privately managed until July 12, 2007, thus attendance data is not readily available. All pre-Hoover libraries and museums are organized and maintained by non-federal agencies.

Now President G. W. Bush is in talks to locate his library at Southern Methodist University, his wife's alma mater. While the libraries are a helpful tool for historians and academics, some are also big tourist attractions.

Here is a ranking of presidential libraries/museums by 2006 tourist attendance:

Ronald Reagan, Simi Valley, California – 440,301

William J. Clinton, Little Rock, Arkansas – 302,151

Lyndon B. Johnson, Austin, Texas – 210,473

John F. Kennedy, Boston, Massachusetts – 191,986

George H. W. Bush, College Station, Texas – 140,674

Harry S. Truman, Independence, Missouri – 135,316

Franklin D. Roosevelt, Hyde Park, New York – 108,589

Dwight D. Eisenhower, Abilene, Kansas – 69,248

Jimmy Carter, Atlanta, Georgia – 62,223

Gerald R. Ford, Grand Rapids, Michigan – 58, 784 (greatly increased after his 2007 death)

Herbert Hoover, West Branch, Iowa – 50,077

Source: Washingtonian Magazine

WHAT IS SOCIAL MEDIA?

Babak Afshar

Editor's note: The so-called "new media" – blogs, wikis, RSS feeds – are becoming increasingly important for the informal learning community. Conventional information-based media (e.g. network news), traditional cultural experiences (e.g., museum visits, symphony concerts, etc.), and pre-packaged information products (e.g., CD's, books) are facing increasing competition from new media. Informal learning organizations, including museums, need to take advantage of new media and incorporate it as an integral part of learning resources. New media is a natural for informal learning; much of it depends on self-directed exploration and learning. For example, instead of buying a set of encyclopedias, you go online and find what you need and perhaps even contribute some of your own information or creations. This article provides a "New Media 101" overview for those of us who are still beached in the old media.

A new form of media has emerged online, generally referred to as 'social media.' As many things nascent and net-born, there is no cookie cutter definition of what social media *is* but the essence of what it *does* can be summarized as a group of technologies that share certain traits. These collective attributes of social media are:

Democratic: Social media is based on participation of contributors and users in an open and transparent environment. The medium's audiences are constantly contributing to the message. Through feedback and open participation social media effectively eliminates the traditional media boundaries that separate spectators from the spectacle. To be a spectator or a lurker is discouraged while participating, voting and making your voice heard is the goal.

Collaborative: The most striking difference with traditional media's unidirectional broadcast of content, is that social media is bidirectional; a two way conversation dependent on user generated content. If traditional media takes the form of diction by broadcaster to the consumer, social media is a back-and-forth cooperative discussion. As a collaborative tool social media affords time-shifting, and place-shifting while presenting a common view of the content to all participants.

Communal: Social media is community oriented. Whereas traditional media aims to communicate to individuals and households, social media tries to build communities of interest based on quick and effective communication. It provides a place to gather with anyone, anywhere, at anytime sharing any common interest. Communities of interest exist and proliferate around any concern or curiosity that two or more people share.

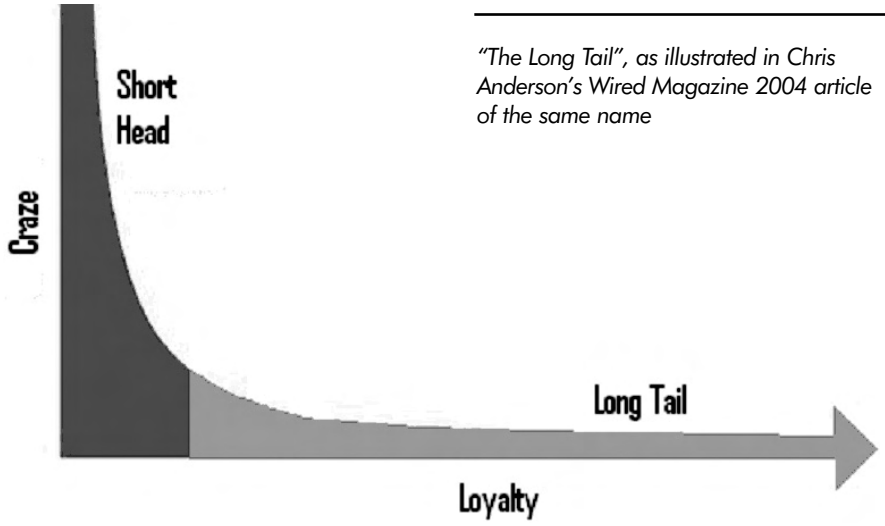
Interconnected: Although the early world wide web introduced the notion of hypertextual connectivity, social media takes that one step further. It accelerates the speed and simplicity for gathering and presentation of seemingly disparate technologies such as audio, video, telephony and print all in one place intertwined for instant participation, conversation, collaboration, syndication, and community building.

Although these characteristics may sound very familiar individually and in fact they are, they have never been brought together collectively with technologies that are so accessible, inexpensive and relatively simple to use in order to serve what has been called the long tail.

The "Long Tail" originally discussed in *Wired Magazine* (Anderson, 2004) pointed out the increasing relevance of smaller distribution channels of more varied products for longer periods of time to a greater number of niche communities as opposed to the short head of traditional mass marketing of a single product for all, in a quick burst of time (see Figure 1 below). The long tail of social media as a medium becomes the message through user interaction. Social media technologies fall in the long tail of this curve in that they build communities of trust among loyal members who contribute as well as create content.

Various forms of social media exist, all of which cannot be covered at once. But some of the main forms we can discuss here include *blogs, podcasts*, *social nets, folksonomies, wikis,* and some *web aggregators* and *mashups*. Almost all types of social media bring various forms of media such as audio, video, text and so on together and make it simpler for a community of users to interact with the content as well as with one another.

The most well known of the technologies of social media, blogs, essentially chronicle on a regularly updated basis, the common thoughts, interests and actions of an individual or a group of people. "Blogs" or "web logs" evolved from daily updated online journals kept by some internet users in the early 90s who later began to develop code to automate their daily publishing process. The new publishing systems were soon to be known as blogs, their authors as bloggers and the process as blogging. The blogosphere refers to the discourse generated and discussed in the blogging universe. Blog readers are what make this form of technology a type of social media; the readers are active contributors to the conversation by freely commenting and continuing the discussion on any blog post, often with the author of the post as well as



"The Long Tail", as illustrated in Chris Anderson's Wired Magazine 2004 article of the same name

other readers. An example of blog is the newly launched Tech Council blog located at *www.drtvtechnology.org*.

As a particular form of audio narrowcasting, "podcasts" are similiar to blogs in that they can be syndicated and users can subscribe to the audio stream of the podcast to receive regular updates automatically. A podcast is distinguished from other forms of downloadable or streaming audio files in that the subscribed podcast is automatically downloaded to a device using standardized feeds. Once the user has subscribed to the syndicated feed of a podcast, they can choose the type of device on which to play back the audio file. The *podango.com* website offers an array of free daily podcasts for feed-based subscription.

"Social nets" refer to online social networking communities built around individual nodes and their relationship or degrees of separation to other points or nodes on the social network. Key individuals placed at a nexus point around which a cluster of users gather on the network tend to have higher relevance and greater sociocultural clout on the social net. Examples can be social networks formed around particular interest such as *MySpace*'s initial focus on independent music and partying, or around particular institutions such as *LinkedIn*'s focus on work and business networks, or *Facebook's* focus on educational institutions. Another aspect of social networking is its unintended effect of regional popularity which forms a new type of social net as it grows. For instance the popularity of *Google's Orkut* grew exponentially higher in Brazil and Iran as compared to other regions of the world. Later when Iran censored the site, *Orkut* became somewhat synonymous with a Brazil-centric social network.

"Folksonomies" form another type of social media by collectively labeling and categorizing content in an open environment for later retrieval by any user of that content. Folksonomies stand in sharp contrast to the other human endeavor of knowledge organization known as taxonomy. In a folksonomy the authors and users are typically one and the same, and the content is often created by the author who 'tags' his or her creation. This labeling or 'tagging' process generates new types of databases with higher relevancy factor as each piece of content is tagged by its most critical user or creator. As these tags and labels are generally shared knowledge among users of a particular folksonomy, the generated databases simply future searching, retrieval, discovery, navigation and even repurposing of the content. Famous examples include *del.icio.us* for social bookmarking of websites and *flickr.com* for photo sharing.

"Wikis" (pronounced "We-Keys") are content management systems that allow for easy reading, writing, deleting, and general editing of the available content without necessarily having to register as a new user. Its goal is easy collaborative authorship and it accomplishes this by allowing collective writing to become an act of exceedingly simplified interaction within a web browser. As with other forms of social media, all wikis are user generated and user-maintained. The best example of this is the free online encyclopedia located at *Wikipedia.org*.

There are other forms of social media such as *mashups* and *aggregators* that collect various sources of news and information and present it in a different yet useful manner. These are sites such as *digg.com* (social news), *popurls.com* (popular urls), *deals.com* (shopping deals), *retrevo.com* (product reviews), *originalsignal.com* (blog aggregator) and the mashup site *mappr.com*. They essentially gather information and repurpose it using open programming standards or the notion of "wisdom of the crowd". Both group intelligence and an open exchange of information on these websites lead to a more integrated web application, a better social media.

All of these forms of social media are shaped around communities which are extremely passionate and individuals who are experts within the community in which they participate. In our research at Xionic Media we have found time and again that the loyal long tail of this participation has significant value for the advertising world by allowing the wisdom of the crowd or the community to be a part of the conversation which forms the message being delivered. Whether the message is in the form of an expert business blog, a daily podcast, greater presence and recognition in a social net or a particular folksonomy, content generators or users are the first and foremost audience whose conversation should inform marketers and not the other way around. If advertisers listen to these communities before they broadcast a message of one-size-fits all mediums, then they will be duly rewarded by the loyal long tail of the communities in which they want to become a part.

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SCIENCE ON A SHIP

A creative partnership between Royal Caribbean Cruise Lines and the University of Miami's Rosenstiel School of Marine and Atmospheric Research is providing valuable data on ocean and climate conditions in the western Caribbean Sea and Atlantic Ocean. It also gives passengers on the elegant *Explorer of the Seas* a first-hand look at scientific research in action.

With funding provided by the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA), high-tech laboratories process and report out on data gathered continuously as the *Explorer* carries its 3,000+ passengers on their cruises from Miami to the Bahamas and Puerto Rico as well as to Jamaica and the Yucatan Peninsula.

Instruments on the ship's masts measure wind speed and direction, barometric pressure, relative humidity, air temperature, and solar radiation. The scientists also study the concentrations of gases and particulate matter in the air, leading to better understanding of the origin, concentration, and variability of air pollutants. Sensors in the bow of the ship collect data on the ocean's salinity, temperature, oceanic plant life, and oxygen content. Lastly, tools on the underside of the ship use sonar to measure ocean currents and marine organism populations.

Data is gathered and processed in two laboratories, one devoted to atmospheric sciences and one to ocean sciences.

The economics of this partnership are stunning. Royal Caribbean invested $3 million into the laboratories, and sets aside one cabin on every cruise for the scientists. Since the program started in 2000, 280 scientists have conducted research on the *Explorer*, and are able to send their data to the University of Miami labs via the ship's satellite link. The university's annual budget for such research is about $600,000. Under normal circumstances it would have to lease a research vessel for about $30-$40,000 per day, using up that budget in two to three weeks. Under this arrangement, scientists are at sea for about forty weeks per year.

In addition to the university-based research, Royal Caribbean encourages private industry to test new prototype research equipment and ideas.

Scientists working on the *Explorer of the Seas* give public presentations to interested passengers and provide guided tours of the laboratory facilities, in addition to interacting with guests in informal settings. This has proven to be an interesting inducement for travelers to book on that ship – and some return multiple times to watch the science in action.

It is also quite a change of pace for the scientists as well. Not all oceanographers work in such luxury, with the temptations of the midnight buffet, floor shows and casino! Scientists from around the world are eligible to get their projects onboard. According to a recent CNN report, the waiting list for positions is about five months long.

The Explorer of the Seas