Informal Learning

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CONTENTS

HIP-HOP MUSIC AS BRAIN FOOD

Baba Brinkman

When it comes to informal learning, there aren't many platforms less formal than rap music. The signature sound is a thumping kick-snare beat complemented by catchy looped melodies and staccato rhyming verses. Rap is clearly good for expressing the thoughts and emotions of the rapper, good for boasting and swagger, good for getting the dance floor moving, but is it good for communicating ideas and information? Some rap artists and educators have come think so.

Full disclosure: I'm one of those rap artists. Writing and performing rap has been my sole source of income for the past ten years, during which time I have released nine full length albums, written four hip-hop plays, and toured the world.

A few years ago I developed a project to communicate the essence of Charles Darwin's theory of evolution by means of natural selection through a series of rap songs and comedy sketches. The result was *The Rap Guide to Evolution*, which functions as a rap album, a theater piece, and a teaching tool. Ever since I moved into science communication via rap, researchers in diverse fields have been approaching me with requests: "Could you do a rap about climate change? Chemistry? Medicine? Wilderness conservation? Economics? Cancer? Biotech? Microbiology? Probability and statistics?" Not all of these projects will come to fruition, but the answer to each question is "yes."

The most recent "yes" that I pursued came from Athena Aktipis, the Director of Human and Social Evolution at the University of California San Francisco's Center for Evolution and Cancer. Athena studies evolutionary models of cancer

"Hip-Hop," continued on page 2

THE POWER OF OBJECTS: INTERACTIVES IN OBJECT-BASED NATURAL HISTORY GALLERIES

Claudia Gorr

The 'bodiless' visitor, who passively absorbs knowledge through looking, is gladly history for many natural history museums. Writing in the year 2013, we have accumulated evidence that multisensory interaction plays an important role in learning about natural history (Cox-Petterson, 2003) and multisensory items can improve conventional natural history exhibitions (Davidson, et al., 1991). We are, however, still unsure about the circumstances in which interactives can support meaning-making in natural history museums. We are also still exploring what kinds of interactives support learning in such museums best. My case study at the Finnish Museum of Natural History (LUOMUS) identified some clues regarding these questions. I was furthermore interested in determining the most suitable methods for measuring such clues and thus provide evaluators at other natural history museums with a helpful framework.

As a part of the University of Helsinki, LUOMUS has an excellent reputation for its research and collections. From 2008 to 2011, the entire museum building was refurbished from the ground up, not only in architectural regards but also with regards to pedagogical thinking . Educators were included in the planning from the beginning in order to establish truly interpretive exhibitions. One of these, the permanent History of Life gallery (figure 1), tells about the development of life in light of latest research findings. In addition to conventional objects such as fossils, rocks, mounted animals and skeleton models, the exhibition also offers opportunities for active learning and sensory experiences. These are nine touchable rocks and fossils (figure 2), two peephole-walls or boxes for observation, two interactive

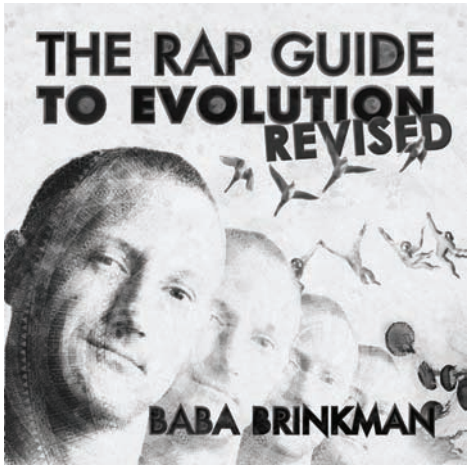
"Objects," continued on page 5

"Hip-Hop," continued from front cover

development, and has helped to reframe our understanding of the disease through a Darwinian lens. Cancer cells "cheat" the rules imposed by the body and instead compete and reproduce relentlessly, returning to the behavior pattern of their (and our) single-celled ancestors. Athena and I worked together to devise a peer-reviewed rap song – "Revenge of the Somatic" – which tells the story of a tumor from the perspective of a "rebel cell." [1]

I used to be a slave myself; I felt senescence hastening
Before my carcinogenic awakening
A couple hundred thousand puffs of tobacco smoke and
I just wasn't as open to apoptosis
That's a bad prognosis, I was hit with every tumor suppressant
Mechanism in the human immune system
But I mutated with it; I was super-persistent
Every daughter cell was suitably different – therapeutic resistance
Came to me like a beautiful vision
I really thought I was doomed, but evolution assisted
With the chemotherapy, so clever and devious!
But I was already genetically heterogeneous
You just deaded the weakest, now competitive release is
Inevitable, now witness as my fitness increases
Entering untapped niches, I gather the benefits
I'm relentless; I get fed from angiogenesis
Duckin' T-Cell predators, I keep it anonymous
So I can exploit the body's weakness and tolerance
I'm a smooth criminal, so I never get caught
I just pimp the system like credit card fraud

The Rap Guide to Evolution remains my flagship "proof of concept" for the potential impact of science communication via rap. The show premiered off-Broadway in New York in 2011 and ran for five months, six shows per week, reaching more than ten thousand people. I have also toured it to Australia, Hong Kong, Europe, and around the UK, including many shows for high school and college students, some in the American South.



At a high school performance in Tennessee one of the questions from the student audience was: "If Jesus comes and blows up the world, what will you think of evolution then?" Another question (from a fifteen year old girl) was: "So, are you saying we *should* have sex, or we *shouldn't* have sex?" My answer was simple: "Evolution can't help you decide whether you should or shouldn't have sex, but it can help explain why you'll REALLY want to."

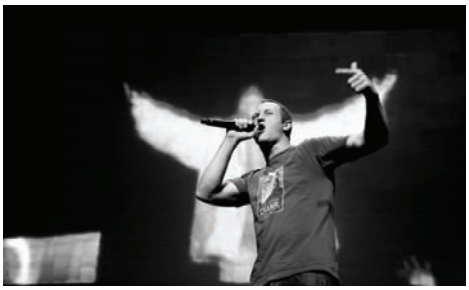
Last summer I had the honor of sharing a stage with Stephen Hawking at the Seattle Science Festival. With Hawking watching from the side of the stage I devised an improvised freestyle rap, joking: "Stephen Hawking's watching me, and it feels like a credit check / 'Cause I bought his book years ago, but I haven't read it yet." One of the stage hands told me afterwards that he cracked a smile at that line. (Scratch that off my bucket list: "Made Stephen Hawking laugh – check.") I haven't yet had the honor of opening for Jay-Z, but then again, Jay-Z hasn't had the honor of opening for the world's smartest man either.

I first caught on to the teaching potential of rap as an undergraduate student of comparative literature in 1999. The assignment was to re-tell one of Chaucer's *Canterbury Tales* in a "modern voice," a brilliant informal learning technique employed by professor Sheila Roberts, the resident medievalist at Simon Fraser University (now retired). Instead of assigning her students to simply give a presentation on *Sir Gawaine and the Green Knight* or *Beowulf* or Edmund Spenser's epic poem *The Faerie Queene*, Sheila would have us adapt the stories into a modern context and perform them as a piece of drama. Acted out by my fellow students and me, Spenser's Redcrosse Knight became James Bond, surrounded by seducers and villains, and the characters, Una, Duessa, Sans Foy, etc, still clearly inhabit my memory.

For the "modernizing" assignment in my *Canterbury Tales* course, I set about rewriting Chaucer's *Knight's Tale* into a rap style, which a group of us performed for the rest of the class. Chaucer's language is rich with metaphor and wordplay, perfect for the rap idiom. Later I revised and memorized the twenty-minute piece and set it to music, performing it at talent shows and open mics and family gatherings, and in October, 2000, on a trip to England some graduate students helped me arrange a performance at the New College Antechapel in Oxford. Enthusiastic audiences encouraged me to keep performing and writing. The general feedback was: "It's cool because I understand the story now."

A few years later, Cambridge University sponsored me to do a tour of British high schools, performing *The Rap Canterbury Tales* for more than 1600 students in 30 schools as a literary outreach initiative. In addition to retelling the 600-year-old stories in a way that revitalized them, I carried a passionate message: rap and poetry are essentially the same. Chaucer may seem old and "establishment" and rap may seem new and "edgy" but that's just an illusion created by the winnowing perspective of history. Seen from a wider vantage, Chaucer was the rhyming storyteller of his time, and Jay-Z and Kanye West are the rhyming storytellers of this time. The elements of the craft that appeal to live listening audiences haven't changed a bit: humor, wit, vivid storytelling, sharp metaphors, relatable characters, clever wordplay, and attention to the details of human conflict, love, family, betrayal, jealousy, morality, greed, desire, etc.

After four years of spreading this "rap is poetry" message while touring *The Rap Canterbury Tales* to festivals, schools, theaters, and comedy clubs around the UK, I received an email from Dr. Mark Pallen, a professor of bacterial genomics at the University of Birmingham. Mark asked me: "Could you do for Darwin what you did for Chaucer?" I was no Darwin expert but I was interested in evolution, so I accepted the challenge and began working on *The Rap Guide to Evolution*.



Baba at work

Communicating Darwin with rap was trickier than communicating Chaucer with rap, because Chaucer's stories, characters and dramatic monologues are ready-made. They are already funny and insightful and highly accessible (except for the Middle English language barrier). So with Chaucer all I had to do was retell the stories from *The Canterbury Tales* in my own words. With Darwin, it seemed I would have to invent stories, characters and dramatic monologues from scratch, and have them communicate the science.

With a little research, however, I discovered there were ready-made Darwinian stories as well. They had been staring me in the face my whole life but I had never recognized them for what they were. I'm talking about rap songs. I read Geoffrey Miller's book "The Mating Mind" in which Miller writes: "All of the significant evolution in our species occurred in populations with brown and black skins living in Africa… Afrocentrism is an appropriate attitude to take when we are thinking about human evolution."[2] In that striking passage, Miller had already made the link to hip-hop culture, all I had to do was take the next step. "Afrocentric" rap music by groups like Dead Prez, X-Clan, and Brand Nubian routinely proclaimed: "If you're Black, then you're African," as a statement of Black Nationalism. Evolutionary theorists had a similar message, but with a pan-humanist twist: "If you're Homo sapiens, then you're African." I adapted the Dead Prez song "I'm A African" into a multi-racial anthem proclaiming the unity of common descent of all living humans.

No I wasn't born in Ghana, but Africa is my mama
'Cause that's where my mama got her mitochondria
You can try to fight if you wanna, but it's not gonna change me
'Cause it's plain to see, Africans are my people
If it's not plain to see, then you're eyes deceive you
I'm talkin' primeval! The DNA in my veins
Tells a story that reasonable people find believable
But it might even blow your transistors
Africa is the home of our most recent common ancestors
Which means human beings are all brothers and sisters
So check the massive evidence of Homo erectus
And Australopithecus afarensis in the fossil record
And then try to tell me that we're not all connected
The fossil record has gaps, but no contradictions
And it complements the evidence in your chromosomes
So I came to let you know about your ancestral home!

The original Dead Prez song "I'm A African" wasn't written to appeal to freckled Canadian caucasians like myself, but

"Hip-Hop," continued on following page

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"Hip-Hop," continued from previous page

through the evolutionary lens it spoke directly to me. The chorus of the song is more challenging in performance, because it requires a precise call and response and most audiences need to prompted (some white people feel uncomfortable loudly proclaiming their African roots in public places).

Through trial and error, I found I could get the audience on board with an opening preamble. After carefully presenting the overwhelming evidence that yes, all seven billion living humans share a common ancestor in Africa only a few hundred millennia ago, and yes, Africa is the *only* place on the planet to which *all* living humans can trace their ancestry, the crowd would get right into it. Ironically, Dead Prez were attempting to write a politically and racially exclusive rap song, but they unintentionally wrote the *most inclusive song ever written in history*. Once the audience has savored this irony, regardless of race, they get enthusiastic, and there is no joy like witnessing hundreds of people, white, black, asian, arab, latino, etc, all shouting in unison: "I'm A African, and I know what's happenin'!"

Other latent connections emerged as I mined hip-hop culture for evolutionary insight. When Pras from the Fugees raps "Too many MCs, not enough mics / I exit your show like I exit the turnpike" he is expressing one of the fundamental insights that inspired Darwin's theory: The Doctrine of Malthus. Thomas Malthus' essay *On Population* made an essentially mathematical argument: reproduction causes geometric increases that quickly outstrip resources, if not for differential survival. If every creature that was born survived, we would be neck-deep in organisms. Nature's limited resources logically produce what Darwin called a "struggle for existence" that is one of the main drivers of natural selection. "Too many MCs, not enough mics" expresses that same fundamental insight in the rap ecosystem. Not everyone who wants to be a famous rapper will succeed, because audiences are a limiting resource. Hence, rappers experience a struggle for attention that parallels the struggle for existence in nature, and that struggle drives the (cultural) evolution of the genre.

Further links between Darwin and hip-hop culture emerged when I included evolutionary psychology and the roots of human behavior. Martin Daly and Margo Wilson's *Homicide* research catalogues murder rates in various regions, seeking the environmental triggers that universally predispose us to violent behavior. Their findings show that the main triggers for violence are high levels of income inequality and low male life expectancy, which create high stakes winner-takes-all competitions among young men striving for wealth and status and ultimately for mating opportunities.[3] These behaviors and the environmental triggers that precede them can be found in all racial and cultural groups, but the psychology is never more clearly articulated than in gangster rap music.

The other mating strategy found ubiquitously in rap looks less like the elephant seal and more like the peacock: ostentatious wealth displays. The obvious parallel between a peacock's tail and "bling" barely needs pointing out, but no one had explored the biological parallels in an actual rap song until *The Rap Guide to Evolution*.

Finally, if we can agree that a world with more people mating like peacocks and fewer people mating like elephant seals would be a better, less violent, more amusing place to live, then perhaps Darwin can help us get there. Most attempts to meddle with human genes are rightly condemned along with the gruesome eugenics of the past, but there is one form of intervention I think we can all agree is safe: mate choice. As long as we are free to choose our sex partners and spouses, we are free to use those choices to align the good of our own families with the good of the species. That's why *The Rap Guide to Evolution* concludes with an anthemic call to arms entitled: "Don't Sleep With Mean People."

An enthusiastic theater audience

Anecdotally, many audience members, reviewers, students and educators have attested to the usefulness of *The Rap Guide to Evolution* in helping novices to appreciate and understand biology. However, testimonials and anecdotes are not data, so the next challenge is to subject my audiences to before-and-after impact assessment. One preliminary study conducted by a Masters student in Anthropology found my audience's ability to answer fact-based multiple-choice questions (ie "According to the fossil record, where did the modern human originate?") increased by an average of 11% during the show, but the study had methodological flaws and a small sample size (N = 80) and needs to be repeated and refined. [4]

In the meantime, more rap artists and educators have been catching on to the teaching potential of hip-hop with increasing enthusiasm. A recent project in New York entitled Science Genius B.A.T.T.L.E.S. (Bringing Attention to Transforming Teaching, Learning and Engagement in Science) had high school students compete to create the most cogent and stylistically impressive rap songs about science.[5] Students who had never taken an interest in science before were newly inspired to look up facts on their own time in an effort to improve their lyrics. The project was run with input from Wu Tang Clan's GZA and Columbia University Professor of Education Christopher Emdin, as well as the rap lyric annotation website RapGenius.com. The GZA's forthcoming album, *Dark Matter*, was written with input from scientists at Harvard and MIT.[6]

In the end, informal learning will only integrate hip-hop through the active participation of hip-hop practitioners. The art forms associated with hip-hop culture are difficult to master but easy to imitate badly, and both fans and artists remain vigilant against disrespectful appropriation. The potential for hip-hop to reach vast audiences with good ideas gleaned from science and literature and other scholarly fields is mostly untapped thus far, but the artists with the ability to bridge this gap are not idle. They are honing their attention-getting skills by performing live shows and writing catchy songs, making their mark on popular

culture with little regard for the latent "informal learning potential" their work also carries. Rappers and educators have a great deal to learn from each other, if they can follow Christopher Emdin and the GZA in recognizing the mutual benefit these exchanges have to offer.

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[1] Wu, Corina, 2013. "Peer-reviewed Rap, Pearly Ratchets". *Chemical and Engineering News*. Issue 91, vol. 28 , p. 40, Newscripts. Online journal. http://cen.acs.org/articles/91/i28/Peer-Reviewed-Rap-Pearly-Ratchets.html

[2] A French, AC Kamil, DW Leger, eds (2001). *Evolutionary Psychology and Motivation*. Vol.47 of the Nebraska Symposium on Motivation. University of Nebraska Press, Pp. 1-36.Note:this *.pdf file was prepared from the manuscript and not from the published paper. ftp://psyftp.mcmaster.ca/dalywilson/Papers/NebSympSingleSpace.PDF

[3] Dobbins, Laura. "Rap Music and Evolution: Educational Opportunities" on Baba Brinkman's Website. http://www.bababrinkman.com/wp-content/uploads/2013/08/Dobbins-HAE-Rap-Guide-IP-Fall-2011.pdf

[4] http://www.bababrinkman.com/wp-content/uploads/2013/08/Dobbins-HAE-Rap-Guide-IP-Fall-2011.pdf

[5] http://www.wired.com/underwire/2013/07/rap-science-genius-gza/

[6] Carmichael, Mary, 2011. "Science and 'the genius'. Boston.com website. http://www.boston.com/news/local/massachusetts/articles/2011/12/03/at_harvard_and_mit_the_genius_meets_the_geniuses/

"Objects," continued from front cover

Figure 1: The History of Life gallery. photo: Mikko Heikkinen/LUOMUS

exhibits for exploring rocks and fossils, one big board game, two 'hidden text displays' that can be accessed by opening a small door and one book resting on a lectern that can be flipped through.

There are also 16 white boxes (figure 3) surrounding the core design of the exhibition, which contain hidden displays making references from ancient life forms to contemporary life.

Methods and resources

I applied a multi-strategy design by collecting relatively even amounts of qualitative and quantitative data that were integrated during the interpretation of my findings. In order to enhance validity, I employed three different methods of data collection (Silverman, 1993). A **questionnaire** captured quantitative data through

Figure 2: Touchable rock
Photo: Jani Järvi/LUOMUS

Figure 3:White boxes (hidden displays)
Photo: Jani Järvi/LUOMUS

scale items as well as qualitative data through open questions on demographics, expectations regarding natural history exhibitions and learning style preferences. Here I included a learning strategy test developed by the British Museums, Libraries and Archives Council. An **observation** phase followed which – by means of a rigorous pre-classification and structured schedule – sought to get as much insight as possible into subjects' unbiased, individual behavior, preferences and learning strategies. After the visit, a short semi-structured **interview** was supposed to deliver a deeper insight into individual experiences and help me interpret and understand the observations I made at the exhibition. Whereas the quantitative data was meant to determine

"Objects," continued on following page

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how intensively each single interactive exhibit was used, the qualitative data helped to interpret the findings and went below the surface of merely observable and countable behavior.

Fourteen people of different ages from 25 to 76 (median age 40) and various educational backgrounds and interests took part in the study. There was an even number of females and males, as well as immigrants and Finnish mother tongue speakers. The sampling was, however, non-representative with regard to statistical relevance. All exhibition texts were exclusively in Finnish and Swedish, the two official languages of Finland. Non-Finnish or Swedish speakers were provided with an English-language brochure which did not exactly follow the display structure.

Implementation

To begin with, I determined the exact positions and number of interactive elements in the exhibition and subdivided them into different categories which I marked on the map (figure 4).

I had decided to evaluate subjects' interaction with a 'mark' from 0 to 3 with '0' being no interaction at all and '3' being very intensive and persistent interaction. The visitors would know they were being watched but would be unaware that I focus on how they engage with the interactives. I had identified those points in the gallery from where I would be able to observe the participants without interfering too much. To enhance reliability, I would ask each one to walk through the exhibition as they saw fit, which also allowed sparing those exhibits he or she was not interested in. A live sketch on the exhibition map would help me track each person's individual way through the exhibition including his or her personal priorities.

Each questionnaire/observation/interview session lasted an average of 70 minutes. Four participants went through the exhibition by themselves; the other ten came in pairs. An assistant supported me so that both participants could be observed at the same time. To eliminate variables, I carried out all interviews myself and with each person individually. Thus, even people who visited the exhibition with somebody else were still forced to report their individual memories, interests and opinions and could not be influenced by their partners. I had decided to prompt memories of and opinions about the interactives only at the end of the interview. My intention was to find out whether the participants themselves started talking about them when reflecting on their exhibition experiences. In this way I sought to get a glimpse of how important people really considered the interactives and I could avoid comments that were just made for the sake of pleasing me.

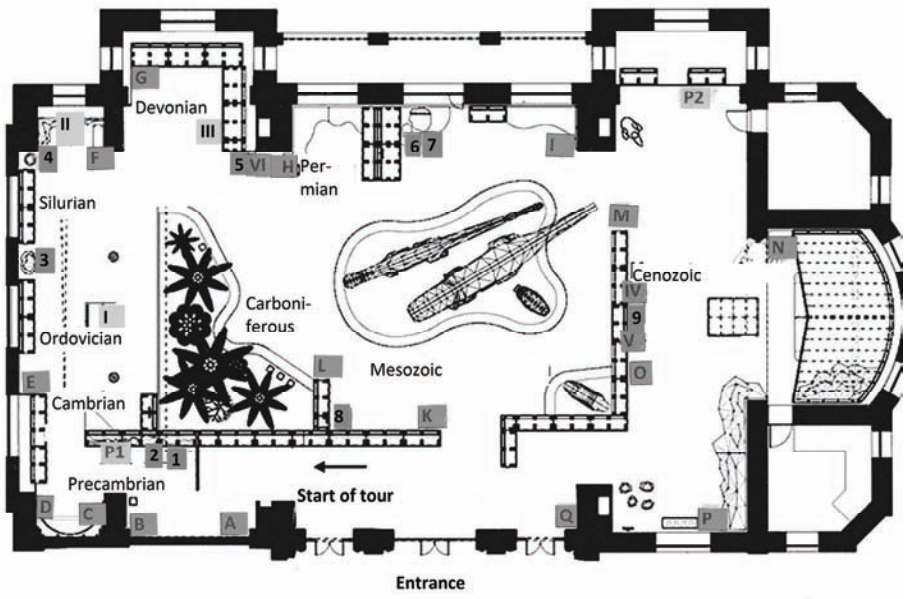

Figure 4: exhibition map displaying all interactive exhibits: touchable rocks and fossils (1-9), white boxes (A-Q), peepholes (P1, P2), rock exploration table (I), fossil wall (II), hidden wall displays (III, IV), book on lectern (V), big board game (VI)

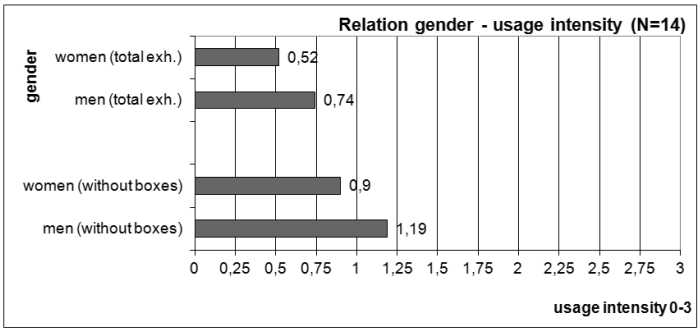

Figure 5: average usage intensity men vs. women

Findings

My observation data shows that, with the exception of one, all participants used the interactive exhibits. From the marks 0, 1, 2 and 3 that I had used for rating everyone's individual usage intensity for each exhibit I was able to calculate each person's average usage intensity (sum of marks divided by 17, the number of interactives). My aim would have been to plot the average usage intensity against those properties asked in the questionnaires such as age, educational background, museum interest and learning style. Admittedly, though, the analysis yielded very unspecific data. I realized that some characteristics, such as interest in science, could simply not be detected by two four-point scale items. Due to the small sample, subgroups also turned out to be very uneven in number (e.g. 12 kinesthetic learners versus three naturalist learners or three participants with 'low museum interest' versus seven participants with 'average interest'). I came to the conclusion that ascribing these groups certain characteristics related to the exhibit using behavior would be unreliable and presumptuous.

"Objects," continued from front cover

However, my data indicates that gender might play a role. Figure 5 shows a slight discrepancy between the average usage intensity of men (1.19 out of 3.00 for all 17 interactives plus the 16 white boxes and 0.74 out of 3.00 for the interactives without white boxes) and women (0.90 out of 3.00 for all 17 interactives plus the 16 white boxes and 0.52 out of 3.00 for the interactives without white boxes).

Also, there is a weak indication that mother tongue speakers, those who were able to read the exhibition labels, used the interactives a little more intensively (average mark 1.18) than people with a low Finnish language proficiency (average mark 1.00) who had to rely on the English-language brochure that was difficult to handle as it did not exactly follow the display structure. This is illustrated by figure 6 which lists all marks for people with low language proficiency (number 1) in comparison to native speakers (number 3). Average marks are indicated with a black bar. I decided to neglect the mark for the only intermediate speaker, participant five (f, 29). She showed an exceptional behavior by using only one interactive exhibit. It also has to be emphasized that the numbers for low language proficiency and mother tongue speakers are unequal (five versus eight). A comparison is therefore difficult but it might be enough to merit a potential research question for a follow-up study.

Figure 8: Most intensively used interactive: rock exploration table
Photo: Jani Järvi/LUOMUS

The data enabled me to evaluate the average usage intensity for each exhibit (sum of individual marks divided by number of participants). It is rather difficult to compare the six categories of interactives because they exist in varying numbers. Consequently, I decided to illustrate a usage intensity ranking for all single 17 interactive items (plus the white boxes as *one* item).

Figure 7 indicates that the opportunity for exploring rocks with a magnifying glass (figure 8) at the beginning of the exhibition was used most intensively with an average mark of 2.50 out of 3.00. Also the most successful touchable rocks turned out to be those situated in the first part of the exhibition (numbers 1 and 2, see map), whereas comparable touchable rocks (numbers 4 and 8, see map) seemingly lost their attraction due to awkward placement. Surprisingly, in sixth place is the relatively conventional book on the comparison of animal and human skeletons with an average usage intensity of 1.23 out of 3.00. Peephole box P1, which is situated within easy view at the beginning of the exhibition, was apparently more successful than the peephole wall which hides the peepholes within a big animal painting. The white boxes (position 16 on graph) proved to be rather unpopular exhibits (with an average usage intensity of 0.21 out of 3.00). Many participants were observed to not open any of them; others used only one or two. The interviews confirmed that people had assumed the boxes to be either storage boxes or toys for children. This certainly emphasizes the importance of instruction labels. In consideration of the fact that the boxes were actually just hidden displays and stood separately from the rest of the exhibition I decided to exclude them from the following usage intensity calculations.

How popular were the interactives among *all* available elements in the exhibition? As I explained before, I did not do the same detailed assessment for other elements (e.g. specimen, models) as I did for the interactives. However, I drew a map of each visitor's way through the exhibition in which I also marked each

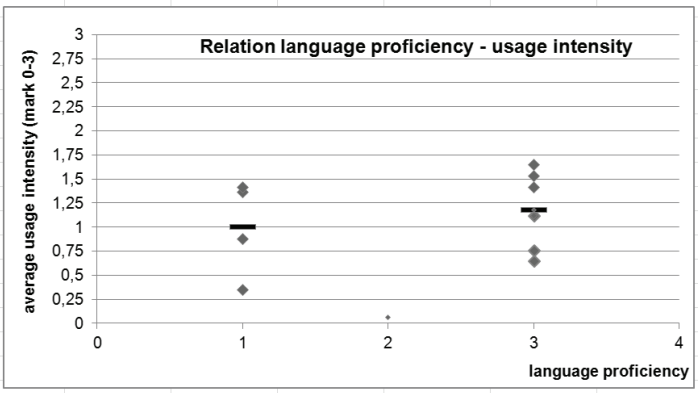

Figure 6: usage intensity as related to language proficiency

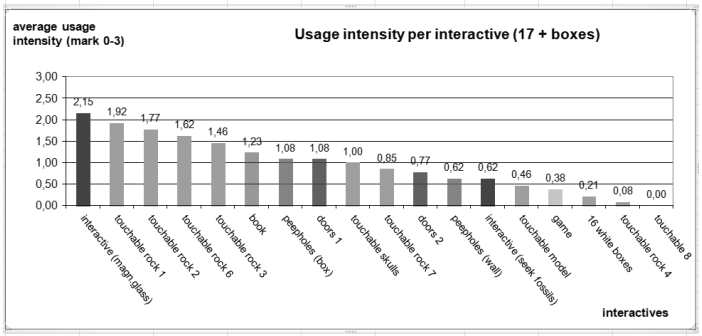

Figure 7: usage intensity ranking for all single 17 interactive items (plus white boxes as one item)

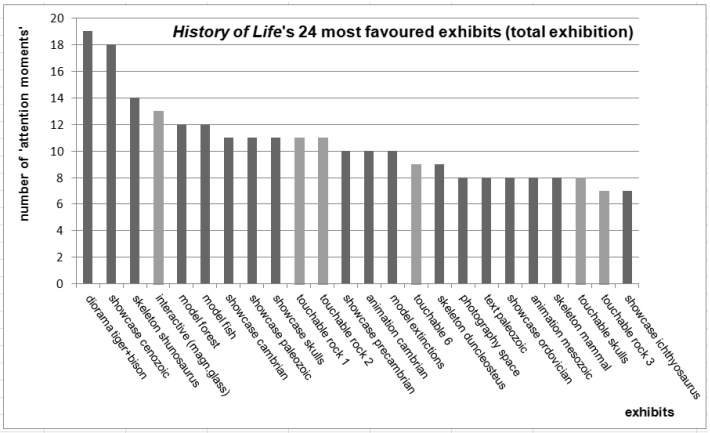

Figure 9: The 24 most popular elements in the exhibition referring to the number of 'attention moments'

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"Objects," continued from previous page

person's foci ('attention moments'), those points where someone stopped in order to look, touch or read. Figure 9 lists the 24 most popular elements in the exhibition referring to the number of 'attention moments' that I totaled for each exhibit.

Among these 24 exhibition elements are only six interactives. This is not much, taking into consideration that there were 33 interactives altogether. Mounted animals and bones of extinct species proved to be outstandingly successful in the History of Life exhibition, with the diorama of a Saber-toothed tiger (figure 10) and a bison family ranking first. As the number shows, there are even more 'attention moments' for these elements than study participants, meaning that some people went back there once again after looking at something else. The most successful interactive, the one for exploring rocks with a magnifying glass, ranks fourth with 13 'attention moments'. It is closely followed by the touch stations 1 and 2 with 11 'attention moments' each. However, the touchable rocks shared their degree of popularity with three showcases and were outrun by a fish model and a model of an Carboniferous forest (figure 11) with 12 'focus moments' each.

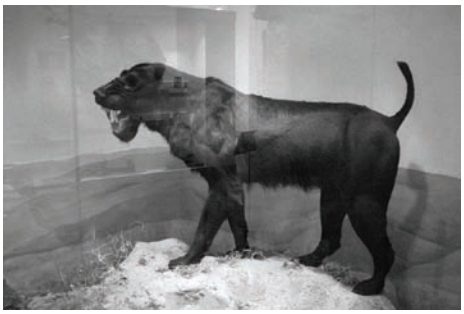

Figure 10: Saber-toothed tiger diorama
Photo: Jani Järvi/LUOMUS

Figure 11: Carboniferous forest model
photo: Claudia Gorr

How much is this observation data supported by the qualitative data from the interviews? People were asked to name the most memorable and impressive elements in the exhibition. Participants mostly mentioned themes and main issues (altogether ten references) that were basically supported by texts and illustrations, as for instance "early life formation," "development of the Baltic region" or "the vast history of life." They also named concrete models (11 references) such as "the sabre tooth tiger," "the bug fossil," "the dinosaur head" and issues that were concretely related to the models and skeletons like "I learned how big those animals actually were." All in all, there were only four mentions relating to the learning content of the interactives like the book, the peephole wall and the white boxes. Also, participant 12 (f, 53), mentioned that "the exhibition engaged all senses."

In how much did people think the interactives supported their learning? Among all statements, there was only one concrete reference to the educational contents of the interactives: participant four (f, 28) mentioned the book, interestingly the most conventional of all interactives, which made her reflect on the relationship between human and animal skeletons.

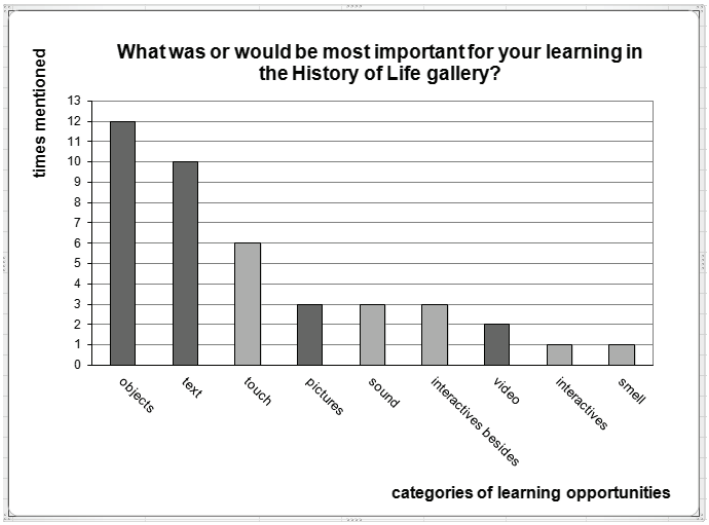

Figure 12: Elements most important for participants' learning (multiple answers permitted)

Figure 12 shows the elements that people rated as most important for their learning (multiple answers were permitted). It clearly illustrates that rather conventional learning methods such as looking at objects (12) and reading texts (10) were considered most important. Interestingly, "touch" ranks in third place with six mentions, followed by "sound" and other kinds of interactives that were only mentioned three times. It is rather important to notice that these three people considered the interactives as a sensible complement to texts and objects, not as stand-alones. Only for one person, participant two (f, 26), were the interactives more important than any other learning method.

In the questionnaire, participants were asked what they would generally like to learn from Natural History Museum exhibitions. Three major topics could be extracted: 1) *conventional themes* such as 'life of extinct species', 'physiology', 'bones', 'curiosities', 'animals', 'unusual nature', 'rocks' and 'interesting objects', 2) the '*bringing-objects-to-life'* theme such as 'animal behavior', 'life' and 'animals in motion' and 3) *contextual or environmental themes* such as 'environmental issues and sustainability', 'regional issues' and 'how living environments determined animals'.

Asked about preferred learning methods, conventional ways of learning again found their way into the questionnaires such as "more facts, not only visual experience" and "see and learn". However, there is a noticeable demand for more physical activity and involvement of the senses stressed by such statements as "learning by walking around," "more video," "more audio," and "more immersion

and interactivity." People also saw a definite need to be able to make interpretations from the objects. They asked for "exhibitions on defined themes" and "exhibitions for everyone."

Discussion

Regarding my methods, the interviews and the observation proved to be very powerful tools. The map, the table-structured observation sheet, and the four assessment categories made the observation process clear and relatively easy to handle. The marks enabled me to express a person's usage intensity and make meaningful calculations. For another study I would suggest two observers evaluating one visitor at the same time. The mean of both evaluators' 'marks' could then be calculated, which would enhance reliability.

The interviews produced rich data and allowed for deeper insights into the participants' individual experiences. I consider them as absolutely necessary for both supporting the quantitative data and their adequate interpretation. Without the interviews I could not have investigated visitors' motives for *not* using certain exhibits and I would not have understood that a high usage intensity does not necessarily mean people are fully satisfied with an exhibit. For instance, most of the participants complained that the interactive with the highest usage intensity, exploring rocks with a magnifying glass, was lacking sufficient light.

To my disappointment, the questionnaires brought about relatively unspecific data. They would need revision, especially in that ways need to be found to evaluate science interest and general museum interest in a way that makes it possible to plot these properties against the individual usage intensity. Another drawback was that some participants were not motivated to complete the questionnaires. In another study this could be improved through an interview-based questionnaire. Also, the MLA learning style test demands improvement or needs to be substituted (e.g. Honey and Mumford 2000) as it lacks reliability and validity. The major problem was that each learning type was evaluated by only two questions, which surely is too few. However, in order to enhance the overall validity and reliability of the data the three different measuring tools questionnaire, observation, and interview could be applied again in a follow-up study.

As for quantitative results, I had to base my evaluation on a small (N=14) non-probability sample for feasibility reasons. In a possible follow-up-study probability sampling (e.g. simple random sampling) would be needed for calculating statistically relevant correlations, which would have more explanatory power with regard to relationships between usage intensity, gender, and language ability.

Despite its potential for improvement, my pre-study work was able to identify a few important indications in reference to the research questions.

Nearly all participants were observed to use the interactive learning opportunities, with a slight indication that male visitors and native speakers used them more intensively. Nevertheless, conventional elements such as models and texts proved to be most important for learning. This leads to the assumption that experiences with real specimens and models are as crucial as ever for natural history museums. The interviews and questionnaires disclosed a rather physical and emotional experience with the artifacts. People talked about "feeling the atmosphere," "feeling the power of things," "being intrigued," and "experiencing big animals up close." The fascination and power of real artifacts in natural history museums has also been described by other researchers such as Cox-Peterson et al., 2003, Xanthoudaki, 2003, and Shuh, 1982.

However, my findings also provide evidence that users need to derive meaning from objects and put the objects into relevant contexts. Visitors with understanding difficulties did not engage more but less with the interactives than Finnish speakers. This obviously led to an overall poorer experience. On a scale from 1.00 (worst) to 5.00 (best), non-speakers rated the exhibition 3.0 on average, whereas native speakers rated it 3.7 on average. Objects simply could not be put into meaningful contexts – neither with the help of texts nor by using the interactives. This reinforces demands of museum researchers (e.g. Ravelli 1996, Hein 1998 according to whom museum objects should be interpreted and contextualized by means of text. It also recalls what Cakir 2008), Preston 2007, Kirschner et al. 2006) and Hein 1998 state about pure exploratory and hands-on learning being ineffective if not used purposefully.

Interactives, especially those opportunities for touching original rocks, were nevertheless found to play a certain role in people's learning processes as suggested by all three research methods. These findings are supported by Cox-Petersen et al. 2003, Hein 1998 and Davidson 1991 who found that multisensory items supported the intellectual and physical accessibility of exhibition objects. Once again, we conclude that interactive exhibits in natural history exhibitions are not in and of themselves successful without bearing certain qualities.

Conclusions

My findings allow the following conclusions:

1. As for design aspects, interactives should harmoniously integrate in an exhibition on natural history while the emphasis can be on objects, texts, and general scenography.

2. Regarding content-related aspects, interactives should sensibly support the exhibition theme and not just be there 'for the sake of interaction' (comment by study participant six, m, 30). As Cakir (2008: 202) puts it, "a trendy emphasis on 'hands on' will not, by itself, increase students' understanding of science."

3. Interactives should be placed strategically, should be easily visible, and should give clear instructions *how* and *why* to use them.

4. The emphasis should be on engaging the senses (hearing, seeing, touching, smelling), which may better support learning through emotions. Interactives should help people 'immerse' into ancient life rather than just being passive observers (Hooper-Greenhill 2007).

5. Original materials, e.g. rocks, feathers, fur, scent, authentic sounds should be involved.

"Objects" continued on following page

"Objects," continued from previous page

6. Exhibitions may make use of a range of virtual tools (e.g. 3-D animation) in order to let extinct animals become 'alive' and illustrate their behavior and interactions with their natural surroundings.

7. Considering the feedback from the interviews, I see a potential for the interactives in raising questions and posing challenges. For example, some participants were disappointed with the 'rock investigation' table as one could not do much more than look at stones through a magnifying glass.

Surprisingly, my data suggests that viewing objects and texts are still most important for learning in exhibitions on natural history. It would be advisable to support this finding by detailed quantitative observations. Data on how long and how intensively people engage with texts and objects should be measured and juxtaposed with the data I gained from observing people's 'attention moments.' My findings also lead to the assumption that interactive exhibits need to be put into a meaningful context rather than providing this context for other objects. These outcomes constitute a fruitful ground for further discussion and research as they, for instance, challenge opponents of exhibition labels (e.g. Leyland 2011).

All in all, my study seems to be a confirmation of what Metzenberg (2000) argues: "Hands-on investigative activities ought to be sprinkled into a science program like a 'spice'; they cannot substitute for a 'main dish'." However, my findings also provide reason to believe that it depends very much on the quality of the interactives as to how important they become for learning.

One theme recurred throughout my study: the need for visitors to immerse in ancient life on earth and to experience how extinct species came to life. In order to make this possible, tools such as wall projections, sound installations, theatrical lighting and animations need to be applied and improved, as it has happened for instance at the Draper Museum of Natural History or in the Desert Night room at the Finnish Museum of Natural History. Along with interpretive texts and original artifacts, I consider immersion to be the keyword for learning processes in future natural history museums.

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SAWICKI'S SERMON

A minister was completing a temperance sermon.

With great emphasis he said, 'If I had all the beer in the world, I'd take it and pour it into the river.'

With even greater emphasis he said, 'And if I had all the wine in the world, I'd take it and pour it into the river.'

And then finally, shaking his fist in the air, he said, 'And if I had all the whiskey in the world, I'd take it and pour it into the river.'

Sermon complete, he sat down…

The song leader stood very cautiously and announced with a smile, nearly laughing, 'For our closing song, let us sing Hymn #365, 'Shall We Gather at the River.'

ANCIENT ORIGINS OF INTERACTIVE DISPLAYS AND SCIENCE SHOWS

Mike Bruton

Graham Walker's comprehensive review of the history of science shows (Informal Learning Review issue 116, September/ October 2012) makes interesting reading, although Michael Faraday is wrongly attributed to the Royal Society of London; he was employed by the Royal Institution in London. But the main problem with this and other reviews of the subjectis that they ignore the very interesting contributions made by early Muslim scholars to informal science education, using both interactive displays and science shows. These contributions were made in their Houses of Wisdom, research laboratories, astronomical observatories, teaching hospitals and early universities during the Golden Age of Islam (ca 800-1400).

The first and most famous House of Wisdom was established by Caliph al-Ma'munin Baghdad in the early 9th century and attracted a coterie of interdisciplinary scholars who dominated the intellectual scene for nearly 500 years. They were not only concerned with translating ancient knowledge into Arabic, and making novel theoretical contributions to science, but also with the application of their knowledge and the design and manufacture of useful technologies.

Furthermore, as required by the Islamic faith, they placed a high priority on recording their knowledge and passing it on to future generations. It was apparently common, in these early places of teaching and learning, for scholars to sit on the ground with members of the public, including children, to discuss advances in science and technology and to demonstrate their points using interactive devices and scientific apparatus.

The glitterati in the first House of Wisdom included the philosopher, mathematician, musician and astronomer, al-Kindi, inventor of decryption and musical theory, the mathematician, astronomer and geographer, al-Khwarizmi,'father' of algebra, and Hunaynibn Ishaq al-'Ibadi, a prominent physician and translator. But, from our point of view, the most interesting scholars were the three Banu Musa bin Shakir brothers, engineers, mathematicians and inventors, and also, apparently, practical jokers!They published 20 books on engineering including one, 'The Book of Ingenious Devices', in which they described one hundred of their 'trick devices'.

Modern reconstruction by MTE Studios of the Banu Musa brothers' "Wudhu Machine" which used siphons to deliver water at regular intervals.

Their innovative devices are, in my opinion,the precursors of modern interactive displays, and they used them to demonstrate the principles of mechanics, hydraulics and pneumatics to other scholars and to the public.They would not be out of place in a modern science center today.

Their devices were playful, interactive and noisy, and typically made use of water and air pressure, intricate pipes, chambers, floats, valves, plugs, animal models and sounds. For instance, their 'Drinking Bull' robot has a bull drinking water and then making a sound of contentment, whereas, in the 'Magical Flask', red water poured into one side of a flask emerges as green water on the other side.

In the 10th century another Muslim mechanical engineer, al-Muradi, made extraordinary automatons and mechanized stage sets five centuries before Leonardo da Vinci and others. His robotic lions, camels and horses adorned public parks at the time, where they both amused and educated the public about mechanical mechanisms. He also published a remarkable book with the intriguing title of 'The Book of Secrets in the Results of Thoughts', in which he described 31 interactive models and how to use them for teaching. His spectacular 'Castle and Gazelle Clock' used water wheels, siphons and pipes as well as gear systems that were lubricated with mercury.

But the most amazing ancient inventor of interactive devices was al-Jazari, who was most active in Turkey from 1176 until his death in 1206 while he was in the service of the Kings of Diyarbakr. He designed and made programmable mechanical and hydraulic robots on a grand scale that not only showcased the advanced state of engineering in the Islamic world at that time but also provided valuable teaching opportunities.

Most importantly, he described his inventions in such intimate detail in his 'Book of Knowledge of Ingenious Mechanical Devices' that we have been able to build them today. Several of his inventions, and those of the Banu Musa brothers, are included in MTE Studios' traveling exhibition, 'Sultans of Science'.

Al-Jazari's most famous works include giant water clocks, robotic slaves and fountains that dispensed water. His 'Elephant Water Clock' not only told the time (within half an hour) using a ball run and water flotation mechanism but also celebrated the universality of Islam by including elements from Persia (carpet), Greece (hydraulics), India (elephant, mahout and *ghati* water mechanism), Arabia (falcon and scribe), Egypt (phoenix), and China (dragon). His 'Castle Clock' had an orchestra playing musical instruments, as did the 'Musical Boat'. His 'Scribe Clock' was the first portable clock, and his 'Robotic Boy' and 'Fountain of the Peacock' provided useful services to the King and his court while also demonstrating mechanical principles. His 'Perpetual Flute' used reduced air pressure to make a whistling noise.

"Ancient," continued on following page

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Miniature of Al-Jazari's iconic water clock, which was a work of art and an interactive educational display.

Al-Jazari used water and air pressure to produce sounds and demonstrate the principles of pneumatics and hydraulics in his 'Perpetual Flute'.

Many other Muslim scholars made interactive edutainment devices, and there were, also, practical scholars from other cultures who preceded them and from whom they learned valuable lessons - Hero of Alexandria (with his steam turbine) and Archimedes (with his screw) come to mind. I believe that it is important to acknowledge the multi-cultural origins of interactive displays and science shows. They have a much more interesting lineage than a sole derivation from Europe as scholars from many other cultures, both ancient and modern, contributed to their development.

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LEARNING BY ACCIDENT, EDUCATING BY PLAN!

Helen Horner

Most of a person's learning is done outside a formal education environment. In an article *The 95 Percent Solution,* John Falk and Lynn Dierking of the College of Science in Oregon State University, contend that the average American spends less than 5% of their life in classrooms. Additionally, an ever growing body of research shows that free-choice learning experiences represent the single greatest contributors to adult science knowledge, and there is no reason to assume that this is not equally true for other learning areas.

There are a great many theories on learning and a great many strategies and processes expounded to optimize the amount and retention of learning. This article does not explore these in any depth, but simply seeks to optimize the learning opportunities to which visitors to our museums and science centers are exposed.

Learning is a process, not a product. It involves change in knowledge, beliefs, behaviors, and/or attitudes. Learning is not fleeting and it is not something 'done' to learners -it is something that learners themselves do. It is the direct result of how the learners interpret and respond to their experiences, conscious and unconscious, past and present.

Several principles of learning, also referred to as laws of learning, underlie the learning process. These include:

- Learning is optimized when the learner has some control over and directs their own learning.
- Things that are freely learned are best learned.
- Learning is optimized when the learning is relevant and meaningful to the learner.
- Learning is strengthened when accompanied by a pleasant or satisfying feeling.
- The learner will learn more from the real thing than from a substitute.
- Interactivity and hands-on experiences optimize the learning process and learning retention.
- People learn in a variety of ways, having a preferred learning style which optimizes their learning.

Otago Museum Entrance

Acquiring learning can occur in many and diverse ways. For succinctness, I have classified these into three broad categories: formal learning, informal learning and accidental learning.

In this broad categorization, **formal learning** covers the learning that a person is exposed to as a result of attending an institution which is purpose-built to offer learning opportunities in a particular or a variety of learning areas. Under this heading are schools, universities and polytechnics. In a formal learning context the learner and the teacher have defined roles and conscious intentions related to the expected learning.

Informal learning covers the learning that occurs outside the formal learning institutions but still has a conscious intent imbedded. People attend informal learning institutions (such as museums, science centers and art galleries), partake in learning experiences, such as shows, workshops, and demonstrations, and read panels, articles and publications, with the intention of being exposed to some sort of learning. It is usually not as structured or deliberate as the learning that occurs in a formal situation and is usually undertaken peripherally to the predominant learning required to estab-

lish a career or life path. Nevertheless, there is a conscious intention to participate in a learning situation.

Accidental learning on the other hand, is the learning that occurs when there is no conscious intent or deliberate plan to learn. It can occur in formal situations and informal situations and has no less intrinsic value than other learning. Indeed; it is how much of our life skills, behaviors and attitudes are learnt.

Museums and science centers fit neatly into the category as places of informal learning. We assume that the majority of our visitors arrive at our institutions with an understanding that they will be exposed to learning experiences and have a semi-conscious intention to depart wiser in some way! How much effort they are willing to invest in this learning opportunity will vary greatly from person to person and from visit to visit. Accordingly, we offer levels of learning experiences to suit the intent, from static displays to information labels, interactive exhibits to demonstrations, shows and workshops. And our visitors participate at the level and for the duration that they choose.

But how well do we provide for accidental learning, capturing the less intentional learner, the visitor who shows no engagement or intention to be caught up in the learning situation? And, should we intervene, or should we leave their learning to 'accident', a fortuitous circumstance which occurs unexpectedly without a deliberate plan or cause?

I contend that the role of museums and science centers is to optimize the range and extent of quality learning opportunities available for our visitors, that we have a responsibility to provide and plan for as much learning within our institutions as possible, even for those visitors who do not visit with any conscious learning intention. Whether the learning is assimilated will ultimately be the choice of the learner. But, if accidental learning is the method through which humans learn a great deal of the skills, behaviors and attitudes necessary to function effectively in society, shouldn't we plan to maximize this learning?

Therefore, as museum and science center educators it is important that we continuously look for ways to provide learning opportunities on all levels and for all people. Carefully planned 'accidental' experiences need to be developed to attract and engage all sectors of the community. The learning may occur 'accidentally' but the facilitating needs to be carefully planned to be effective and valid. By offering a range of well-planned experiences throughout our museums and science centers for visitors to fortuitously 'come across', we optimize the accidental learning that can occur in our organizations.

So, how can we do that? The 'sky is the limit' to planning and providing opportunities for 'accidental learning' in our organizations, but I have included just a few ways that we accomplish this at the Otago Museum and our science center Discovery World to act as stimulants for your own ideas.
Whether the experience fits into the informal or the accidental learning category, all learning experiences at the Otago Museum are developed using a purpose-built planning format which incorporates learning criteria and guidelines. Distinct and measurable learning outcomes and development pathways are outlined. Themes are selected as contexts for the learning based on their potential to engage and stimulate curiosity.

We consistently review our visitors' experiences in our galleries throughout the Museum. We watch, listen and talk with our visitors while they are meandering through our galleries, to discover their interests, their thoughts, their understandings. Then, we plan for them to 'come across' things that will turn their 'just being there, wondering' into 'experiencing and discovering'. We produce *Capture the Moment* packs based around different objects, exhibits and themes which our Communicators bring out when they spy a predisposed visitor with whom they can share.

Additionally, *Living Culture* experiences (having expert practitioners working in the galleries relevant to their skill, for the day, the week or longer), offer a great opportunity for visitors to discover and inadvertently learn something new. This may be a taxidermist, a potter, a drum-maker, an articulator, a costume maker or a fossil extractor who can demonstrate the skills of their craft. Observing and talking with these people can offer visitors unique experiences to learn about the craft and skill required, maybe developing a life-long interest, or just becoming more aware of what is involved behind some of the things they may meet in their everyday lives. If this is able to be offered over a prolonged period, it affords the return visitor the opportunity to see a product or outcome develop through its various stages toward completion.

Explorer Backpacks are a way in which we encourage our younger visitors to explore the Museum and science center with focus and direction. These discovery packs, housed in snazzy backpacks for ease of carrying, have been produced to be multi-level. They can be used independently by a child with a reading age of around 8+, or by younger children with adult guidance and involvement – a great family-focused learning experience. Each backpack has a different area of exploration and is based around a gallery, a set of galleries or a theme. They contain a selection of maps, instructions, props, books, puppets, experiments, activities and information trails and, once again they have been planned deliberately and carefully to lead the user to explore, discover and learn. These backpacksare located throughout the Museum or science center for children to 'come across' in their museum wanderings, or offered to them by Communicators who spy a directionless wanderer!

Discovery Trails are used in a similar manner, as a family-orientated activity to focus and direct visits and provide learning opportunities. Predominantly made up of questions and challenges based around a central theme, these trails require engagement and persistence, leading the participant on a journey around the Museum and/or science centre to search out the answers and solve the clues. With titles such as *Nauseating Nature, The Great Face Farce Detective Trail* and *Pretty Gross,* these have proved extremely successful in engaging both children and adults in the learning journey and thus we now have plans to develop adult level versions.

"Plsn," continued on following page

"Plan," continued from previous page

Wrapping learning in an obscure yet appealing context is a guaranteed way of ensuring people will indulge in learning, whether they intend to or not! Want to help children to learn and understand the life and extinction of the moa (a large native New Zealand bird which became extinct around 1600)? Wrap it in a chocolate 'poo' context! Learn about the habitat, food sources and adaptations of this great bird by exploring its fossilized poo (coprolite). Bring out some real coprolites from the collection for children to carefully observe and discuss with experts how the examination of moa coprolites has allowed us to learn about the food preferences of this amazing, extinct bird. Provide the opportunity for the children to make their own moa coprolites from chocolate with different colored and shaped lollipops to represent the different plants the moa ate. What child will not remember *that* learning for the rest of their lives, wrapped up so well in a gross but tasty experience?

Life is short – we hear that adage throughout our lives and it is so true. So shouldn't we provide maximum opportunities for our people to grow and develop, and enrich our communities with more informed and stimulated members? By turning learning opportunities into unexpected, fun or 'edutainment' experiences, we also set the basis for a passion for life-long learning, something our formal learning institutions often fail to do. And all it takes is some careful planning and a few fortuitous 'accidents'!

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PUBLIC ENGAGEMENT WITH SYNTHETIC BIOLOGY

Natalie Kuldell

Synthetic biology is an emerging discipline that aspires to program living cells to address some of our planet's most persistent challenges. Even in its earliest stages, synthetic biology is transforming our relationship to science, technology and the world around us. As such, it demands constructive and effective ways for the public to intersect with the field. Some ideas for such engagement are detailed here.

Introduction

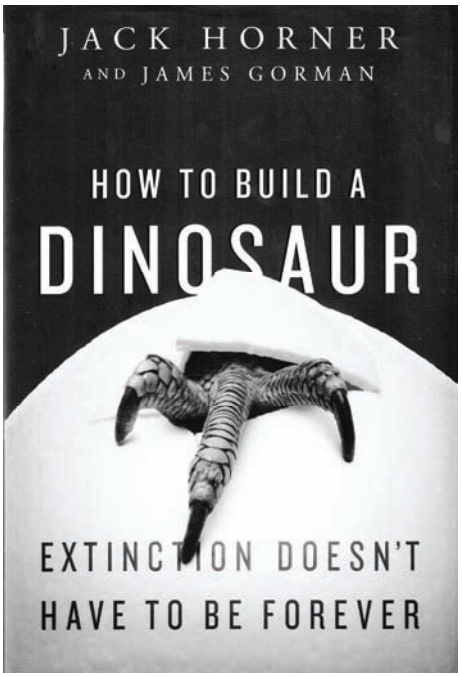
Biological solutions may be our best hope for addressing the challenges that our planet is facing in the 21st century. In order to robustly engineer these living solutions, we'll need new tools for programming cells. The tools will undoubtedly build upon the successes in molecular and genomic biology as well as lessons from other engineering disciplines. This tool-building effort, for better or worse, has been given the name "synthetic biology." Synthetic biology is an emerging engineering discipline that attracts biologists, computer programmers, chemical engineers and social scientists with its intent to redesign the living world through standardized biological parts and automated processes. With its stated goal of reliably constructing organisms that possess novel or enhanced characteristics, synthetic biology has the potential to address many of the most stubborn environmental and health challenges. Potential outcomes include widely available clean water, sustainable fuel, and inexpensive medicines, applications that could make synthetic biology the cornerstone of a robust "bioeconomy" [(1)]. Other potential outcomes, however, include "bioerrors," unintended consequences or changes to a living technology, and "bio-terror" if we presume even some small number of malicious actors. No matter if you believe the utopian or the dystopian view of synthetic biology, they are united in the belief that even marginal success in the field is likely to change the relationship humans have with nature.

The tough questions raised by synthetic biology has led scientists/researchers to consider and discuss their work broadly. Many of the discussions of practice are internal, held among the practitioners themselves. The questions of responsible innovation have been routinely considered in meetings of synthetic biologists [(2)]. The decision to embark on any synthetic biology project must factor in the odds of success, the opportunity costs and the resources required to do a good job. Personal priorities and technical impediments are commonly considered in such academic meetings, as are the public impacts of any project—should it succeed and should it fail. These somewhat private conversations are valuable to the academics themselves and to the sensible development of synthetic biology as a discipline.

The tough questions are also raised outside purely academic circles. Even in its earliest days, the field's efforts to build genetic circuits that reliably program cells drew attention in academic journals like Nature [(3)] and non-academic magazines like Wired [(4)]. The field also has a hearty share of detractors, skeptics and protestors including Greenpeace, Friends of the Earth, and ETC Group. Concerns about the progress and future of synthetic biology are expressed by these groups in public arenas, through protests at scientific meetings [(5)] and in digital spaces [(6)]. As the scope of synthetic biology has grown, so have the broader discussions of the work.

Consider one of the more recent ideas linked to the field, the idea of "unextinction." Anyone with an even passing knowledge of Hollywood movies knows how the Jurassic Park story goes: an island of living dinosaurs is made possible by scientific advances but goes terribly wrong when internal corruption and a poorly planned security system unleash the dinosaurs on the island's visitors. Though the Jurassic Park book and movie predate synthetic biology and are now 20+ years old, the movie's tagline, "life finds a way," still serves as a warning bell to some and a challenge to others. A noted paleontologist, Jack Horner of Montana State University, has

taken up the unextinction challenge and written a book with the subtitle, "Extinction Doesn't Have to be Forever" [7] – appreciating that the vestiges of prehistoric dinosaurs live in the DNA of today's birds. Synthetic biologist, George Church of Harvard Medical School, also recently took up the "regenesis" idea with a book of that title [8]. The social networking and media outlets lit up when Dr. Church, in discussing aspects of this book, seemed to suggest that a surrogate mother was sought to carry and birth a Neanderthal baby. Hollywood visions of the scientific efforts and media kerfuffles loom large in the public perception of synthetic biology, even though it's widely agreed that current science cannot reanimate DNA traces that might turn "chicken little" into *T. rex*. Similarly, practitioners of synthetic biology often discuss tools for engineering biology, tools that could be used to enhance biodiversity by making physical copies of DNA from extinct species, but there is no research push to do so [9].



Public engagement is keenly needed around synthetic biology. Recognizing that "responsible innovation" is a laudable goal with many alternative realizations, what can be done to encourage more productive dialog? Engagement activities, if planned and executed well, would not only inform the public about the active areas of synthetic biology research but they would also help practitioners prioritize efforts in a way that is mindful of society's concerns and perspectives. There are at least four areas for public engagement with synthetic biology, places where informal learning environments would be key. These four areas are active now, but they should be more significantly supported and developed to overcome the amplifier of Hollywood misconceptions and the social media hubbub.

Area 1: That was(n't) easy!

Despite intense interest in the field of synthetic biology, there are few introductory explanations that do not presume a considerable amount of prior knowledge. It's frustratingly difficult to find images that effectively elucidate to a newcomer the parts-based bioengineering approach. Popular images that explain synthetic biology include images of people assembling Lego parts to look like a person, images of wires and circuit boards to run cells, and images of gears and motors moving through the grooves of the DNA double helix. These images are evocative and understandable, adding up to something like "snap together electronics for the construction of living machines." They do not, however, reflect what's state of the art in the field. Lego kits and Arduino programming can be built more easily than DNA circuits, and the notion that living cells are machines is dehumanizing to some and far from truth for all.

Other explanations of synthetic biology rely on recent milestones and achievements in the field. The ability to produce an inexpensive anti-malarial drug, the chemical synthesis of a genome from scratch and the rewriting of a word in the genetic code are often-cited poster children for the field. They all reflect enormous technical and creative breakthroughs. This "explanation by demonstration" approach, though, is not a conversation starter. There are fascinating technical discussions that can follow, but they are not openings for public engagement with the field.

An approach that seems more productive, though little used, is to discuss neither the promises nor the successes of synthetic biology but rather to discuss its struggles. A wonderful example of this was recently written by Dr. Valerie Thompson, who is a Science and Technology Policy Fellow with the American Association for the Advancement of Science [10]. In her article, "Building Better Bacteria," she made an easy-to-understand analogy for the parts-based approach to engineering biology. She asked the reader to think of each biological part as a word in an instructional sentence such as "First, open the box." Simple substitutions give rise to sentences with different meanings such as "First, open the door" or "First, close the box." This would be analogous to swapping in a simple biological part to build a system with new functions. The struggle begins when the context of the substitution is considered. Modifiers can give slightly different meanings to sentences ("First, slowly open the box" and "First open the box slowly") just as cell to cell variation can change the way genetic programs are run. Another complication in building genetic programs is the end-to-end connection that building DNA requires. DNA parts are strung without spaces to separate them, leading to emergent properties, like the word "stop" that appears when the words of the first simple sentence are strung together, "Firstopenthebox".

This short description both describes the efforts in the field of synthetic biology as well as the current struggles. It can be used to initiate a productive conversation, one that does not rely on what's been done or what it promises.

Area 2: Separating fact from fiction

It's uncomfortable for anyone to reimagine what is familiar. Narratives that do so can be powerful and lasting. For example, ask people what comes to mind when they hear the phrase "biological engineering," and often you'll find them describing the image of an ear "growing" on the back of a mouse, despite the many years since the time when the Vacanti mouse was described [11]. Similarly, ask people what they think about when they hear "reliable genetic programming" and you'll find it's science fiction dystopian visions such as the eugenic inequity of the movie "GATTACA." Thus when synthetic biology is caught in a media frenzy about Nean-

"Biology," continued on following page

"Biology," continued from previous page

derthal clones, the comments quickly go to the fanciful ("I want wings" and "grow me a tail").

Of course what's currently possible in the field is worlds away from what's shown in the movies, and far more modest. Thus, a productive approach to engagement could be what Sydney Brenner has called "think small then talk big." If the public's engagement with synthetic biology could begin with what's currently possible rather than with some futuristic vision, then the expectations and perceptions for the field are likely to be more realistic. Easy picking seems to be engagement activities around the charismatic and fun examples of synthetic biology that are driven by a summer competition called iGEM. The international Genetically Engineered Machines competition draws college teams from around the world who compete to build a living machine from standard biological parts. Participation in the competition has grown quickly and the sophistication of the projects that result is impressive. Yet many projects each summer are reasonably straightforward and could be explored as activities with newcomers to the discussion. In a guided fashion, individuals can think through that the building of a novel living system. As described by a high school student who was tasked with explaining synthetic biology to the school committee of his town [(12)], it's possible to start with a section of DNA that allows a cell to sense carbon monoxide and another piece that makes a cell glow green and then put the strings of DNA together to make the cell glow when it senses carbon monoxide. By beginning conversations this way, it's possible to illustrate how the unnatural and artificial products of synthetic biology are still understandable and how they can interact with the natural world in a healthy way.

Area 3: When did I vote for that?

With support from the Sloan Foundation, the Woodrow Wilson Center for International Scholars has recently undertaken a study of synthetic biology and they've posted their work on a publically available website [(13)]. The website reports trends in the field such as the number of researchers involved and the crowd source funding of particular projects. The Wilson Center has also conducted polls to gauge awareness and thinking about synthetic biology. In a recent study [(14)], they report that there is little change in the number of people who have heard of synthetic biology since 2010, the last time their poll was conducted. They also found that the terms associated with the field continue to be words like, "unnatural" "artificial" and "reproducing life." People they questioned in follow-up interviews expressed concerns like, "what stops that organism?" and "who is running this?"

Public concerns such as these might be addressed with reliable open forums for asking questions of experts. The Wilson Center has worked with the "do it yourself biology" community to launch a site called "ask a biosafety expert" [(15)], which provides free professional biosafety advice. In-person models for working with experts such as the ECAST activities around nanotechnology and biodiversity are great working models for engagement that directly addresses public concerns [(16)]. Similarly, the Science Café model has worked well with a great number of scientific issues that raise questions and concerns among the public. Indeed so many science cafes have been carried out around the topic of synthetic biology, including one in Washington DC, another in Seattle WA, and five in Canada, that there is a peer-reviewed publication that draws out the lessons learned from this particular approach [(17)]. It's also worth noting that there are efforts within the community of practicing synthetic biologists to make their work more transparent. For example within the workflow-design tool developed by Prof. Doug Densmore at Boston University there is a freely available "app" for accessing repositories of biological data [(18)], and from SynBERC, the NSF-sponsored synthetic biology research center, there is a "biosecurity learning trail" that is nearing completion [(19)].

Area 4: Don't fence me in

An undergraduate student studying synthetic biology for the first time wrote that the approach "did not really make much sense to me until I was working through it on my own with my own project. Now that I fully understand it, I can easily see why this method is used in living systems design" [(20)]. The experience for this student is hardly unusual yet there are few physical spaces and opportunities for interested individuals to gain first-hand experience with synthetic biology.

Citizen science opportunities in community labs are rare but do exist. For example Genspace in Brooklyn, NY is a Biosafety Level 1 facility where they ask, "remember when science was fun?" and encourage hands-on participation in the new technologies of synthetic biology and personal genomics [(21)]. Their facility works much like a health club in that interested individuals can buy a membership that gains them access to lab equipment and to scientific experts to help them learn to use it. Members can take a class, or work on a project of their own in the lab.

Extending this hands-on approach to formal education settings, BioBuilder is a program that provides current research topics in synthetic biology to teachers and students [(22)]. The lessons begin with online animations that set up the classroom or laboratory challenge for the students and teachers to carry out. Once the experiments have been performed or the topics considered, there is an online forum for teachers to share best practices and students to share data. Supported by a non-profit organization [(23)], the three-part approach (animations to set-up the work, hands-on activities to carry out, then community forums to share findings) has been focused on synthetic biology but could be sensibly applied to other science fields in the near future. Importantly, the content is all freely available online, though the laboratory reagents and the teacher-training programs have some fees associated with them.

BioBuilder.org

Conclusion

This article has suggested four areas in which the public can productively engage in the discussions about synthetic biology, and through which the practitioners of the field can benefit. While this two-way street is not unique to synthetic biology, the opportunities are current and so particularly attractive. In the same way that the emergence of MOOCs (Massive Open Online Courses) has led to a re-examination of teaching and a rediscovery of what has always worked "best" (24), so can the emergence of synthetic biology lead to broad discussions of effective approaches. If successful, the discussions can engender complicated, sophisticated, nuanced and highly informed views. Making sense of this new field, described as "transformative technologies" (25) by some and as "frankenmicrobes" (26) by others, requires we all be clear about what it is and what may happen. And because the new material has not yet been codified to textbooks, an effective approach to engagement will remind us all that science is a "practice" rather than a collection of findings and facts. And wouldn't it be ironic and wonderful if the "synthetic" ends up reconnecting us to our "natural" approach for understanding and improving the world?

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Museum and Exhibition Review

THE EVOLVING NATURAL HISTORY MUSEUM IN LOS ANGELES

Robert Mac West

The Natural History Museum of Los Angeles County (NHMLAC) has just about completed its major transformation into the "indoor-outdoor" museum of the 21st century. Four major elements of the transformation (Nature Lab, Natural Garden, Discover Los Angles exhibition, and the Otis Booth Pavilion entrance) opened during the summer of 2013, with one to appear later this year – the traveling exhibits gallery. These are a $135 million celebration of the museum's centennial. It opened in 1913 as the first dedicated museum in the city of Los Angeles. The NHM Next campaign has been very successful.

This series of physical and programmatic advances began in 2010 with the revamping of its fossil mammal (Age of Mammals) and reptile (Dinosaur Hall) galleries. Please see my commentaries on those two exhibitions in ILR nos. 104, pp. 10-12 and 109, pp. 6-10. The 2013 openings continue the significantly improved visitor and educational experience at the NHMLAC.

The Los Angeles museum is in the company of other U.S. natural history museums that are recasting the approach to study, investigation, and interpretation/presentation of the natural world. I have recently been able to experience and document several other significant exhibitions and institutions in previous issues of The Informal Learning Review. Others of recent note are the new facility and program of the Natural History Museum of Utah, Salt Lake City (ILR no. 112, pp. 112, 120-123), the human evolution gallery at the U.S. National Museum of Natural History, Smithsonian Institution, Washington, DC (ILR no. 101, pp. 9-12), and the Nature Research Center at the North Carolina

"Review," continued on following page

Index, Nos. 115-120

Index, Nos. 115-120

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Museum of Natural Science, Raleigh (ILR no. 114, pp. 8-13).These new installations, taken together, are strong evidence of the movement to museum programming that helps visitors understand how natural history research is conducted and how questions are asked, researched and (sometimes tentatively) answered. It also helps visitors realize that there is fascinating natural history at their doorsteps (even if they live in a big city), and that scientists are continually discovering new things, asking new questions, and expanding our knowledge bank.

The expansion of the NHMLAC's exhibits and programming into the out of doors (hence the "indoor/ outdoor museum) takes full advantage of the Los Angeles climate and the museum's location in Exposition Park – which it shares with the California Science Center, the California African-American Museum, and the Rose Garden and is across the street from the Los Angeles Memorial Coliseum, the football stadium for the University of Southern California and the (former) Los Angeles Rams through 1979.

The four newest areas that opened in 2013 are the Otis Booth Pavilion, the Nature Gardens, Nature Lab, and the *Becoming Los Angeles* exhibition. The new areas continue the restructuring of natural history exhibits and programs into centers where visitors – real and online – are experiencing how scientists are investigating the natural world, how they fashion their questions, collecting strategies, and research agendas. Further, it is focusing on the immediate area, affirming that there are lots of interesting aspects of the natural and human history of Los Angeles and it is possible – yea easy – to see numerous fascinating aspects of nature in the immediate vicinity.

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Otis Booth Pavilion

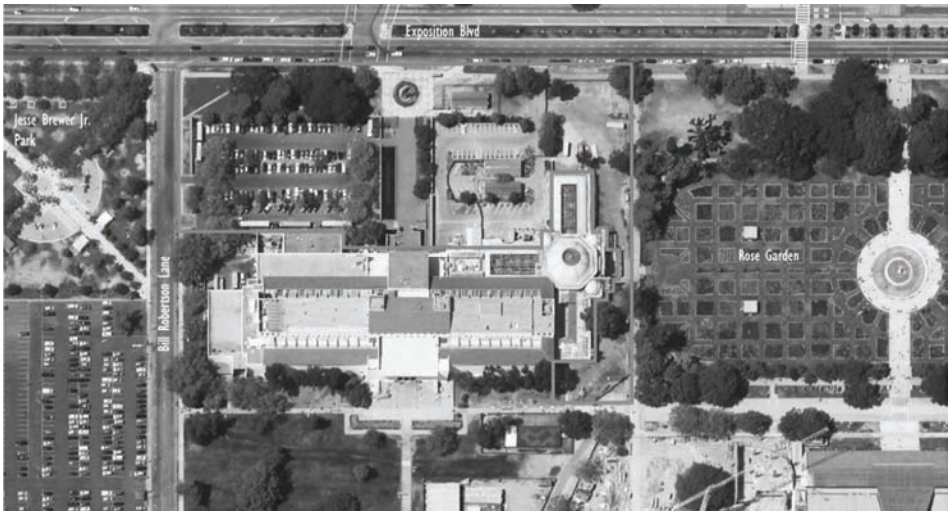
The building itself has evolved, with a new entrance located on the opposite side of the building from the former one. The six-story, all-glass, Otis Booth Pavilion—located on a former parking lot, is now the primary museum entrance and is accessible from both surface parking and convenient light rail stops. An elegant bridge reveals the entrance and the dramatically suspended 63 foot fin whale skeleton hanging inside. The fin whale specimen was previously in a horizontal position in an inside exhibit hall. The ground level of the pavilion connects the Nature Garden directly with the Nature Lab. This installation replaced 153,000 square feet of asphalt parking lot. In the process, 102,000 cubic feet of concrete was crushed and recycled into aspects of the garden structure and walkways.

Nature Gardens

The 3.5 acres of the Nature Gardens used to be parking, asphalt, and generally unnatural. There are several distinctive areas. One area attempts to show the various historic vegetation patterns, while throughout the gardens (the pond, the "get dirty zone", the edible garden and the living wall), plantings have been selected to be attractive to indigenous wildlife, especially birds and insects. Through careful and continuous observation indigenous wildlife are being documented and incorporated into the list of Exposition Park taxa. The edible garden contains various fruits and vegetables. The "get dirty zone" focuses on soil science and is more accessible to younger visitors because of the interactivity. The Living Wall is constructed with big gaps between the vertical rocks. Already various plants have penetrated the wall and make very interesting patterns. The museum hopes these cavities will become home for lizards, but none have yet been seen.

Nature Lab

Nature Lab is on the lower, literally ground, level of the museum with easy access to the outdoor Nature Gardens. It is highly interactive and very engaging to a broad audience. The primary message of the gallery is to stress and demonstrate the great natural diversity of the city of Los Angeles. It claims to be the naturally most diverse city in the United States. There is a facilitated and independent examination of numerous organisms, both animal and plant. The examples include native species, those introduced relatively recently by humans (both intentionally and inadvertently), endangered species and those with reduced ranges and populations, fascinating behaviors, and numerous habitats (including homes and yards). The presentations point out everyday creatures – rodents, ants, songbirds, etc. that can be seen in many places. There is mention of the history of changing environments as the city grew and all manner of materials and organisms were brought in to equip the metropolitan area. This parallels *Becoming Los Angeles* in interesting ways without mentioning it. Live animals on display include snakes, rats, turtles, ants and spiders. Exhibits are grouped under topics including Life on the Edge, Surviving and Thriving, Respect the Rat, New in Town, LA is a Biodiversity Hotspot, and LA's Nature in Real Time.



Aerial view before modifications

The indoor/outdoor museum today.

Both the Nature Lab and the Nature Gardens encourage museum guests/users to join in some fascinating citizen science projects both hosted by the natural history museum and various partners. This clearly is making excellent use of an important trend in public engagement with research projects. The natural history museum manages several projects, including:

- BioSCAN – Biodiversity Science: City and Nature – document which insects live in LA by collecting at home and in the Nature Gardens;

- LLOLA – Los Lizards of LA – investigate why there aren't any lizards living in Exposition Park;

- Los Angeles Butterfly Survey – a partnership with Butterflies and Moths of North America (BAMONA) to share data and learn more about LA butterflies and moths.

An example of the museum working in collaboration with another organization is California Roadkill Observation System (CROS) through UC Davis Road Ecology Center. This citizen science project records roadkills, the species, locations, and possible environmental situations.

The citizen science initiatives are readily accessible on the museum's website at http://www.nhm.org/nature.

Becoming Los Angeles

Becoming Los Angeles is a 14,000 square foot exhibit, the largest in the museum. In a very interesting way it merges human and natural history with a clearly local central story. The basic theme is how humans enter and then reshape their environment, with the Los Angeles area being the environment under consideration. It pronounces that it examines the "relationship between nature and culture, between human activity and the land." "The Los Angeles environment has encouraged human development, while its natural events and transformations have challenged human achievement." (graphic panel).

The exhibition takes advantage of the museum's unusual collections; it started as the Los Angeles County Historical and Art Museum, a name still embedded on the side (original entrance into the Rotunda) façade of the original building.

It starts with Native Americans and their use of natural resources via a hunting and gathering economy. Then Mexican settlers arrived, who formalized the city in 1781. The first change, well documented with artifacts, was the impact of the Spanish mission system which brought with it European style farming with domesticated animals and plants. This conscious manipulation of the land for farming was very different from hunting and gathering. Mexican independence from Spain brought expanded trade; cattle now were raised for trade to the outside for various goods. This clearly changed land use and pressure on the native vegetation. By the time of the Gold Rush of the 1850s and 60s the cattle markets had expanded, herds were larger and overgrazing was extensive. A header announces "Cows changed everything." The late 19th century saw rapid population increase: from 1,610 in 1850 to 50,395 in 1890 to 576,637 in 1920 in the city alone. The oil boom of the 1890s forced out the farms and created new forms of pollution. The exhibition details numerous interesting examples of societal changes – mixed races, segregation, ostracism, etc., with fascinating photographs and portraits. In the 20th century, in addition to the archtypical movie industry (local weather was good for filming and the area offered diverse interesting backgrounds), power from nearby Hoover Dam supported a local aviation industry.

Original entrance with original name

Becoming Los Angeles is either history with a natural history twist, or indication that human history is inevitably affected and/or directed by natural history. Different reviews have treated this gallery very differently. While I was occasionally perplexed by the selection of artifacts and specimens, I enjoyed the intercalation of two usually separate approaches to the evolution of our modern world.

Becoming Los Angeles is a fascinating contrast with both the traditional diorama galleries - African and North American mammals – and the more progressive paleontology halls. The dioramas, literally next door, are still elegant and engaging because of the taxidermy and settings but so lacking in the ability to a) represent the actual diversity and interactions of the organisms and various environments and b) address visitor questions regarding the animals' behavior, anatomy, etc. These are the ying to the Nature Lab/Dinosaur Hall/Age of Mammals' yang. And these very different presentations styles and contents are next door neighbors!

Finale

There is one area still to open. The renovated traveling exhibition galleries are due to be available in late December 2012, and will feature the only North American presentation of the *Traveling the Silk Road: Ancient Pathway to the Modern World* exhibition from the American Museum of Natural History.

Observations

Dr. Jane Pisano and her staff, board, and supporters have done a remarkable job of evolving the Natural History Museum of Los Angeles County. It now offers its guests an array of experiences in the galleries (and this brief commentary does not get into the numerous public programs presented on a regular basis). The various elements of NHM Next make this museum a much more interesting and progressive place. With these advances and innovations in place, we now can look ahead to see what will be next in the natural history museum universe.

The changes at the NHMLAC have been well documented, appraised, and commented upon by the media. As is to be expected, there are some differing opinions, particularly with regard to the style and storyline of *Becoming Los Angeles*. Two very recent posts, one a television video and the other a New York Times review by a prominent museum critic, are well worth tending to: Voice of America, Los Angeles Natural History Museum Redefined, August 9, 2003: http://www.voanews.com/content/los-angeles-natural-history-museum-redefined/1726924.html and Rothstein, Edward, Beyond Dioramas: Nature's New Story, NY Times, August 2, 2013 http://www.nytimes.com/2013/08/03/arts/design/the-remaking-of-a-los-angeles-museum.html?pagewanted= all&_r=0.

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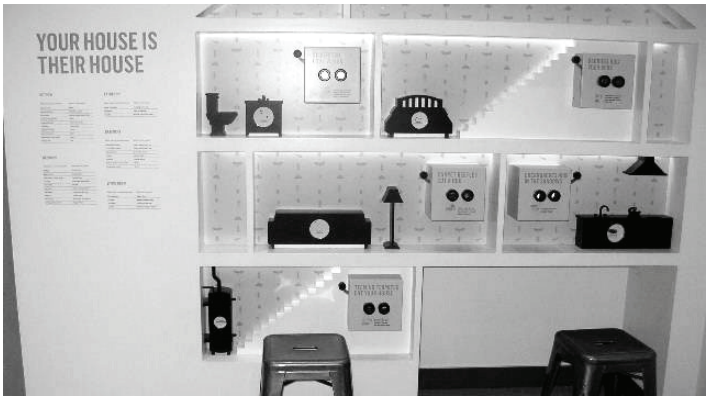
NATURAL HISTORY MUSEUM IN LOS ANGELES

Entry to Booth Pavilion

Whale skeleton in Booth Pavilion

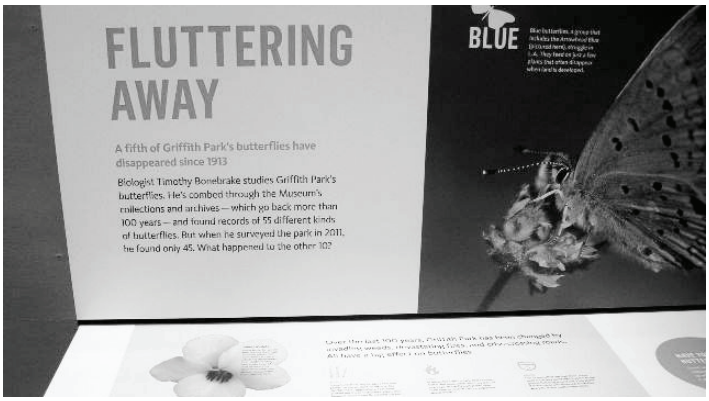
Booth Pavilion from Nature Gardens

Nature Lab identification

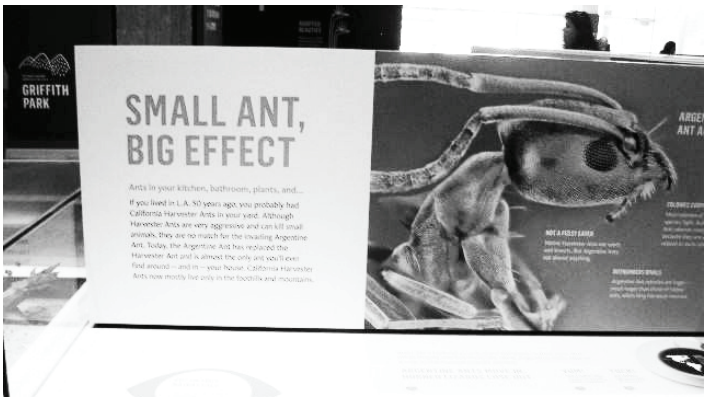


Natural habitats in a home

Nature Lab work station



Nature Lab – butterflies



Nature Lab – ants

NATURAL HISTORY MUSEUM IN LOS ANGELES

Living Wall

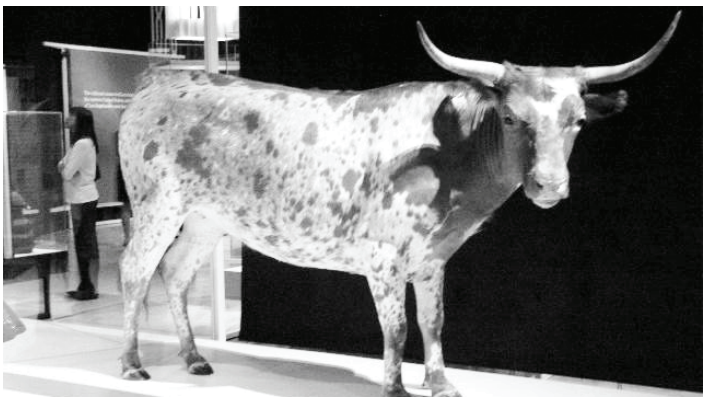
View of Booth Pavilion from Nature Garden

Research in the Nature Garden

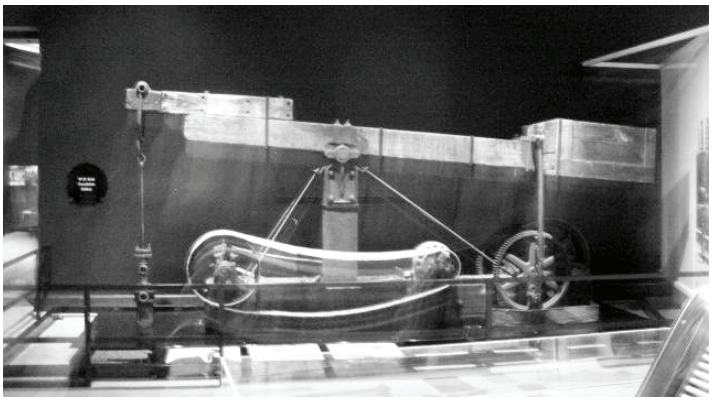
Nature Garden activity area.

Becoming Los Angeles artifacts exhibits

Los Angeles residents over time.



The animal that impacted Los Angeles history



Machinery from the oil boom days

GOULD AWARD TO JUDITH SCOTCHMOOR

The Stephen Jay Gould Prize is awarded annually by the Society for the Study of Evolution (SSE) to recognize individuals whose sustained and exemplary efforts have advanced public understanding of evolutionary science and its importance in biology, education, and everyday life in the spirit of Stephen Jay Gould, a longtime professor at Harvard University and author of many significant publications on the importance of evolution.

The winner of the 2013 Stephen Jay Gould Prize was Judith G. Scotchmoor, the Director of Education and Public Programs at the University of California Museum of Paleontology at the University of California-Berkeley (UCMP). Scotchmoor is an award-winning science educator who has worked for decades to improve science teaching. She delivered the Gould Award lecture at 8:00 PM Friday evening, June 21, at the SSE annual conference in Snowbird, Utah. The title of her talk was "Keeping Science as the Centerpiece: Lessons Learned."

Scotchmoor is noted for her work on UCMP's highly regarded evolution program, including the popular Understanding Evolution (http://evolution.berkeley.edu) and Understanding Science (http://undsci.berkeley.edu) websites, which clock over a million visitors per month. She was also the moving force behind the National Conference on the Teaching of Evolution in 2001, which galvanized scientists and educators to take the growing attacks on evolution education seriously.

ERRATUM: ILR 120 AUTHOR INFORMATION OMITTED

Unfortunately we omitted author identification and contact information for two articles in ILR no. 120. With apologies to the authors, here is that information.

Special Exhibits in Aquariums, by Linda Wilson and Billy Spitzer. Linda Wilson is Director of Impact Assessment at the John G. Shedd Aquarium, Chicago, IL. She may be reached at *LWilson@sheddaquarium.org.* Billy Spitzer is Vice President of Planning, Programs, and Exhibits at the New England Aquarium, Boston, MA. He may be reached at *bspitzer@neaq.org.*

History Colorado Renews Itself, by Arthur H. Wolf. Arthur H. Wolf is Founder and Principal of WOLF Consulting, Las Vegas, Nevada. He may be reached at *ahwolf@wolfconsulting.us.*

ILE'S TRAVELING EXHIBITIONS FORUM AT ALBUQUERQUE ASTC CONFERENCE

As usual, Informal Learning Experiences is organizing the Traveling Exhibitions Forum at the annual ASTC conference. This year's session will be at 7:30 am on Monday, October 21, in a conference room in the Doubletree Hotel, attached to the Albuquerque Convention Center. It will not be listed on ASTC's formal conference program, so all information will come directly from ILE. Invitations to potential presenters will be sent in early September and information on the session will be distributed via our email lists. Interested individuals and organizations should contact ILE at ileinc@informallearning.com to make sure they are on that list.

We are pleased to welcome Global Experience Specialists, Exhibits Rex and Imagine Exhibitions as sponsors of the forum at ASTC.

Exhibition Review

PLASTICS UNWRAPPED IN SEATTLE

Robert Mac West

The Burke Museum of Natural History and Culture of the University of Washington has developed a traveling exhibition that merges history, technology, 21st century culture, and environmental issues in a very interesting way. *Plastics Unwrapped* addresses development, uses and proliferation, and environmental challenges of plastic in a 2,000 square foot three-dimensional environment packed with often-touchable examples of the material being considered.

The Burke Museum regards the plastics exhibition as part of its aggressive move into an environmental advocacy role. It has previously (over the last five years) produced exhibitions on climate change and the impact on wildlife, conservation photography, the Arctic National Wildlife refuge and the changing Arctic landscape. In doing these, it has established relationships with significant off-campus resources.

The exhibit has completed its introductory presentation at the Burke and next will be available in February, 2014, at the South Florida Museum in Bradenton. I visited the exhibit at the Burke and will be very interested in how it is presented and received in off-campus environments.

Celebration and Anticipation

While current ideas about plastics largely deal with the environmental issues associated with a substance that takes huge amounts of time to decompose into its natural materials, *Plastics Unwrapped* begins with an interesting historical narrative of how, within the past sixty years, plastics have come to provide ready, cheap, and dependable access to many materials, objects, instruments, tools, etc., that are central to modern life. Displays of anthropological and household items from pre-WWII days make the point that people were very creative about how to adapt various natural materials to serve a multitude of purposes – everything from raingear to toys to containers to early dial telephones to furniture.

Technology developed during, and in support of, World War II was revolutionary in its creative use of hydrocarbons to form a variety of durable, light, and flexible materials – plastics. This literally caused an explosion in the production of both exotics and everyday items. The contrasts that are provided between "original" and "advanced" things are really dramatic. The differences in prosthetic limbs are exhibited in very helpful fashion. This part of the exhibit also features some fascinating videos of commercials from the 40s and 50s. They are a wonderful celebration of creativity and industry that not only feature the products of their times but also happily anticipate a plastic-dominated future filled with disposable items.

In this section, no thought was given to issues of debris accumulation or environmental hazards such as ingestion by animals or chemical pollution. Of particular interest is an example of the plastics problem-solving accompanied by proliferation is a case that includes all the plastic used in a medical procedure on a museum staff member. Yes, the medical condition was resolved, but the amount of debris that resulted is really quite remarkable.

Medical procedure debris

Reality – and Waste

And then, in the second major part of the exhibit, reality sets in. There are very realistic representations of the sheer volume and diversity of modern plastic use – and virtually uncontrolled disposal and discard of plastic bottles, bags, electronics, and so forth. The exhibits are set up to be scaled so that visitors can see the volume of plastic disposal per person, per unit of time, etc. By connecting volume of disposal with personal behavior and community activities in comprehensible time frames, the magnitude of the environmental issue is made very clear.

Specific aspects of plastic waste and the environmental consequences are featured. They range from specimens of animals entangled in plastics to the stomach contents made up largely of plastic debris and fragments. The display of debris that was collected locally in the Puget Sound coastal area by University of Washington staff in collaboration with local organizations specifically for the exhibit, is a large and diverse pile. Waste from many western countries is sent for recycling in third world countries, where the people doing the recycling are exposed to devastatingly toxic environments – which thus do not have to exist in the developed world. A very graphic video illustrates this. Yet another example is plastic bags collected from local bins of used and discarded materials.

Rethink

A wall toward the end of the exhibit is filled with suggestions/recommendations for how we can rethink our behavior and personal uses and disposals of plastics in ways that will reduce the problem in the future. This can be regarded as directive and prescriptive or, as is hoped, a very logical progression from the dramatic representations of the environmental and economic challenges produced by the modern plastic-dominated society. These suggestions involve more attention to recycling, use of recycled products, reduced plastic packaging, more use of compostable materials, elimination of plastic water bottles and disposable plastic bags (as an increasing number of communities are mandating through surcharges), and general awareness of the composition of things we buy and use every day. They are presented in a low-key fashion, quite different from the dramatic and frequently challenging presentations in more dogmatic formats.

Imagination

The final area (and quite unexpected, given the intensity of the main parts) of the exhibit is one of artistic creativity in which visitors use plastic debris to create art, much of which hangs from the ceiling of the gallery. This is a real transition from STEM to STEAM (Science, Technology, Engineering, Art and Mathematics), as is occurring with increasing frequency in various museums' programming. This area appears to be most attractive to youngsters and teens as well as University of Washington students.

The wall of modern options for coping with excessive plastic.

Plastic artwork hanging from the Imagination ceiling.

Observations

The initial evaluations – conduced in the university environment – are generally positive and supportive. The campus evaluator looks forward to responses and assessments from other museums and their particular communities and environments.

This is a significant exhibition, which I hope will travel well and broadly, because of its creative and intense interdisciplinary approach to a topic that some will regard as too controversial to present in a natural history museum. The Burke clearly doesn't shy away from forcibly and graphically demonstrating the very substantial and largely negative environmental impacts of the proliferation of plastic products as well as public behavior with the disposal of those materials when they are deemed used and excess. But it also places plastic as a very useful and flexible material into multiple cultural and applications contexts, many of which have and continue to make modern life productive and affordable. The last area, where plastic waste is converted into abstract and representational art, is a clever way of encouraging both creativity and recycling.

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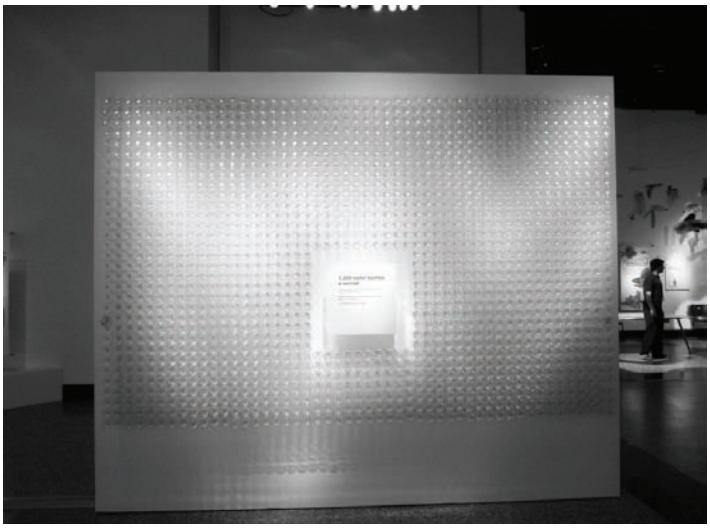
PLASTICS UNWRAPPED IN SEATTLE

Samples of pre-plastic objects and equipment.



Wall of plastic bottles.

Pre- and post-plastic prosthetic limbs and feet

Digital age plastic-based junk – accumulates at 170 pounds per second

Diverse plastic waste

Masses of bottles and other containers

"Game," continued from back cover

Although we would have loved to include a real experiment, this was not possible. So we focused on observation, comparing, sorting and discussing.

Based on these principles Hubbub came up with a game concept that emulated the experience of the scientific process.

The Game

Animal mayhem! The animals are confused. Are they fish, bird, mammal or reptile? Do research and help them! Convince the flying squirrel that he is not a bird!

Visitors are challenged to battle in two teams and help the 'poor animals' to regain their true identity by taking pictures of zoological evidence and characteristics of the true animal class. These pictures, taken under time pressure, are tagged in the app and weighted: are they good or even unique characteristics? The team with the best and most convincing evidence wins. The assignment to take pictures is introduced just to make the visitor focus on the collection. The app does not 'process' the picture in terms of pattern recognition. Nevertheless, visitors are unaware of this 'phoney' use of technology, but watching the collection via the phone provides for an unprecedented level of focus. We make use of the knowledge that the visitors (subconsciously) already have and while tagging, give them clues about more characteristics they could look at.

Experience so Far

The target groups are children aged eight to twelve and their parents or grandparents. They play in teams of two or three players each. Players spend an average of 30 minutes in the cabinet. They focus and think about individual objects, separately and in relation to others. They discuss the objects in an unprecedented way. And it is not guaranteed for the adults to win! The adult's knowledge is matched and often outrivaled by the children's perceptiveness. The team with the best chance of winning is an intergenerational team.

Game Development

The development of the game was an interesting experience. We did not see any computer until very late in the process. Most of the time was spent on paper prototyping. The game was designed on paper and the first prototype that we actually played - with focus groups - was still on paper (that is: cardboard signs). Only then was the software developed and the application produced. Over the last few months we tested it with real visitors and we are now commencing a redevelopment phase. The re-launch will be later this year.

Testing the paper prototype version of Animal Mayhem
Photo by: Hubbub

Playing Animal Mayhem *in the cabinet of curiosities*
Photo by: J. Klaassen

A mixed team together studying Animal Mayhem *on the iPod*
Photo by: J. Kaassen

Not all of the weaknesses surfaced in the tests with the focus groups. They are, in a way, too focused. Only with real visitors did we discover that the game is too long, the screens that we use are too small and that there are complications that put visitors off. The redevelopment will bring shorter loops, reminders of previous tasks fulfilled and an option to return to a previous screen. The iPods that we now lend to the visitor will be replaced by iPad mini's. After the final launch we will offer it in the App-store, so that people can upload it onto their own smart phone or other device.

Conclusion

We will soon have a beautiful tool for visitors to enjoy the *Cabinet of Curiosities*. The collection is part of the game, but did not need any adaptation. The game meets with all criteria that we deem important: it is a social activity, where people stimulate, challenge and help each other. It is inter-generational. Players are involved both mentally and physically. And visitors really study the objects. They study them like a researcher would, completely in line with our mission.

Thanks to: Taskforce Innovation Utrecht Region, Hubbub, and AniekBax (University Museum Utrecht)

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ANIMAL MAYHEM: HOW A GAME MAKES DEAD BIRDS COME TO LIFE.

Paul Voogt and Ineke Puijk

Dead birds are not a magnet for visitors, especially not for children. Not even if they are set in a cabinet of curiosities, with classical furniture and the spectacular skeletons of a hippo and a giant reptile, like in the University Museum of Utrecht (The Netherlands). The average time spent in this room, the *Cabinet of Curiosities,* used to be five minutes. Without changing anything about the presentations, we now have 30 minute visits, with excited families, animatedly discussing the dead birds and other objects on display. What was the magic trick?

Alas, there are no magic trick—it took long and hard work to arrive at the ultimate solution: a game, called *Animal Mayhem*. The game was developed by Hubbub, a design studio who 'specialized in new games for social change', in close cooperation with the University Museum Utrecht.

The University Museum Utrecht is a science museum, reflecting the 375 years of history of Utrecht University. It presents collections, mainly from the sciences. Some highlights are: a Van Leeuwenhoek microscope from the17th century, the original 19th century anatomy cabinet of professor Jan Bleuland, a collection of glass models of marine invertebrates by the famous glassblower family Blaschka and a 20th century particle accelerator. We also have interactive science labs, where children explore and discover. Our main target groups are families and school groups.

The University Museum Utrecht wants its visitors to explore science. We try to engage visitors and get them interested so that they want to investigate, both physically (hands-on) and mentally (minds-on). We are not satisfied with exhibits that only present and explain a phenomenon. Our aim is to get them involved, by addressing not only cognition, but also the senses, and turn a visit into a memorable experience.

The start

Utrecht is a city with a very lively game development sector. Both the university and the art school offer courses in game development and a lot of small start-ups have sprung up in the city over the last decade. The municipal government nourishes this innovative sector and the more established companies are now housed in one big business complex in the city center. The national government offers grants for projects that apply serious gaming to different sectors, one of them being the heritage sector.

The University Museum wanted to gain experience with the value that gaming can add to the visitor experience and applied for a grant, which was awarded. Our goal was to deepen the engagement of the visitor by combining a meaningful visit with a playful experience. We chose the *Cabinet of Curiosities* as a setting for the game. The *Cabinet of Curiosities* is a beautiful presentation space, popular with the visitor, but difficult to hold the attention of visitors for a longer span of time. Some low-tech interactive were already integrated, such as drawers with small manual activities that elucidate some of the objects. Later we followed with an experiment using a precursor of the QR code. Visitors could use their smart phones to access a website with background information. Still, none of these additions really engaged the audience with the exhibits to a level we had hoped.

The idea to develop a game for the *Cabinet* initially met with some resistance in the museum. Many thought of a game as a solitary activity, carried out behind a screen, which absorbs the attention of children in such a way that they will certainly not look at the dead birds anymore. This is however a very narrow definition of what gaming is. It soon turned out that the game developers with whom we worked do not start from technology, but with a question: "how do we turn our visitors into investigators?" Their approach is best described by Hubbub itself: 'Technology is here to serve us, and follows purpose and function'. So we asked ourselves: what is a scientist, how do they work? Based on the principles of the research cycle we identified skills that are typical for doing research and inquiry based learning. The most important skills for a researcher are: to observe, compare, ask questions, get ideas, carry out experiments, sort out, discuss and reach conclusions.

"Game," continued on page 27