Embedding Environmental Enrichment into Zoo Animal Facility Design

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Abstract

Environmental enrichment of managed wild animals has evolved beyond simple remediating additions to inadequate displays. Many zoos, aquariums and animal sanctuaries have or are planning facilities with built-in enrichment features designed to activate natural behaviours and increase physical and mental fitness with far more sophistication than simple climbing ropes, elevated platforms or changeable amusements, important as these are. The goal of environmental enrichment should not only be to improve the well being of individual animals, but also to insure their natural behavioural competence for generations far into the future. This paper is intended to brief zoo designers and others less involved in the environmental enrichment movement by defining useful terms, summarizing recent evolution and exploring new directions in enrichment design. These include the need to fully integrate enrichment "hardware" (physical features) and "software" (management, operation and maintenance programs). There also is a need to update the animal welfare movement's "Five Freedoms" with "Five New Freedoms", freedom to enjoy competence, choice, control, variety and complexity equals practical freedom. Thoughtful, deliberate and inclusive steps in the planning process, based upon recent examples, may provide useful ways forward.

Introduction

For over three thousand years, zoo animals were captured and displayed for the enjoyment, recreation and edification of royalty and other elites and later for the public as menageries. For the last seventy years or so, zoo design was based upon visitor experience, keeper convenience and animal physical health and hygiene, under a philosophy of human dominance (anthropocentrism).[1] Until relatively recently, little was known about the physical, social or ecological environments in which these species evolved and upon which their wellbeing depended. Nearly all zoo facilities were modelled after other zoos, livestock operations or veterinary and laboratory facilities. Animals in such settings tended to be thought of as commodities needing routine service rather than thinking, feeling and dependent creatures until recently. Also, in a culture of copying, incremental improvements can be made, but

[1] Coe, J., 1994

breakthrough insights are rare and real progress is slow. With few exceptions, the idea that "nature should be the model" wasn't considered until the late 1970's[2]

"But in the animal exhibit areas there must be one constant and inherent design philosophy: Nature is the norm." D. Hancocks, 2001, p145.

Evolving enrichment theory

The following defined terms are central to contemporary design for increased enrichment.

Freedom: *"The power of self-determination attributed to the will; the quality of being independent of fate or necessity."* Oxford Living Dictionary Online

Freedom to enjoy competence, choice, control, variety and complexity equals practical freedom. *"The organism with the most choices has the most freedom."*[3]

Beyond the "Five Freedoms **from**:"[4]

- Freedom from hunger and thirst: by ready access to fresh water and diet to maintain health and vigour.
- Freedom from discomfort: by providing appropriate environments including shelter and comfortable resting areas.
- Freedom from pain, injury or disease.
- Freedom from fear and distress.
- Freedom to express normal behaviour.

To "Five New Freedoms **to"**:

- Freedom to Achieve Competence: *"Effective performance of normal functions"* Oxford Living Dictionary online
- Freedom to Have Choice: ***"****The right or ability to choose."* Oxford Living Dictionary online
- Freedom to Take Control: *"The power to influence...the course of events"* Oxford Living Dictionary online
- Freedom to Experience Variety *"The quality of being different or diverse; the absence of uniformity or monotony."* Oxford Living Dictionary online
- Freedom to Engage Complexity: *"The quality of being intricate or complex"* Oxford Living Dictionary online

[2] Jones, G. et al 1976, Hancocks, D. 1980, 2001
[3] Coe, J. 2011
[4] Five Freedoms *www.aspcapro.org/sites/pro/files/aspca_asv_**five_freedoms**_final_0_0.pdf*

Competence: means the animal has the long-term genetic (physical and mental) ability and the instincts and/or knowledge (innate and learned competence) to take the actions required to achieve desired outcomes.

Choice (or "agency")**:** implies means, including access, to the multiple desirable features.

Control: means the animal can decide when, how, where and with whom to go to and/or make use of the feature (or not) without outside interference although outside interference may be needed at first for training.

- "…the importance of work is that organisms with an acquired sense of control will be better able to cope with new problems."[5]
- "…providing animals with environmental control (or work) can reduce the levels of the stress hormone cortisol and levels of aggression and can have major effects on social skills and coping behavior of monkeys."[6]

Variety: and moderate change is also considered beneficial to captive animal wellbeing where lack of stimulation and boredom are common conditions.

Complexity: is also an essential feature for animals which evolved in complex environments. If access, choice, control, competence and variety are provided in a very limited way (and thus not at all complex), this would not be as enriching as if these features were provided in multiple complex and interacting ways. For example, multiple **access** means, multiple **choice. Complexity** can have a multiplying effect on the benefits of the other five new freedoms.

Opportunity: *"A set of circumstances that make it possible to do something."* Oxford Living Dictionary online. However, to access opportunities provided, the animal must have both the **control** and the **competence** to employ many strategies and actions to meet **changing** conditions. The five new freedoms provide abundant overlapping opportunities for enriching activities and behaviours.

Occupation: *"A job or profession."* Oxford Living Dictionary online or "voluntary work" Research has shown animals will work for rewards even when the same rewards are freely available, thus demonstrating the importance of occupation.[7]

Learned helpless and dependency: When animals are taught over-dependence, lose or never develop their natural initiative, they may develop learned helplessness.[8] Special training or reconditioning may be necessary to overcome this challenge and allow captive animals to enjoy and benefit from enrichment programs.

[5] Snowden, C.1989
[6] Snowden, C.1989
[7] Osbourne, S. 1977
[8] paraphrasing Young, R. 2003, p38

Overcoming fear: Some zoo animals are naturally very shy or are fearful in the presence of both staff and visitors and to novel experiences. Wild-caught and rescue animals may be especially prone to this problem. These animals may live in constant fear and distress. No matter how much enrichment is provided, they cannot be said to be provided with a humane life until this fear can be replaced with confidence through careful and patient desensitization training. For the designer, this means providing the animal with retreat areas as well as safe trainer access in suitable locations. While animals must always have the opportunity to remove themselves from stressful situations, in some cases one-way (mirror) glass and sound proofing may give the animal a feeling of privacy while providing visitors with close up viewing opportunities. This strategy was used successfully with timid Mexican wolves at the Brookfield Zoo in Chicago.

Enrichment and physical fitness: Good enrichment programs benefit more than the domain of behaviour. Visit any good zoo and you can admire the healthy weight, clear eyes and glowing fur, feathers of scales of the animals. But if you are familiar with their wild conspecifics, it is immediately clear they usually have slack muscles and, if tested, poor balance, dexterity and coordination. The obvious reason is lack of physical fitness caused by lack of space and incentive to exercise vigorously. Very often poor coordination and balance is exacerbated by have all climbing and perching features of uniform size, fixed and inflexible. It is important that climbing trees and posts and some platforms and perches move somewhat under the animal to help build balance and muscle coordination.[9] Some zoos, the National Zoo of South African in Pretoria is a good example, hang the leopard's daily ration of meat over a swinging platform. This requires the leopard to balance on a moving point while reaching, acquiring and eating the hung meat. This leopard must exert considerable effort and manage balance and coordination at a high level for every bit of meat it receives: it is a very fit animal with superb muscle condition.

Five domains: (current focus of Shape of Enrichment and WAZA training). Another direction advancing the original five freedoms developed by David J Mellor[10] involves thinking of them as five domains including Nutrition, Environment, Health and Behaviour. Each domain consists of "negative/restrictions upon" and "positive/opportunities to" that affect animal welfare. These four domains combine to influence the fifth "affective experience domain", the Mental State.[11] It is the interaction of these that determines animal welfare status and modern enrichment programs attempt to address each domain while providing an effective, integrated all-domain approach to guide their work.

[9] Coe, J. 2006
[10] Mellor
[11] WAZA, 2015. p. 20

Behavioural fitness

Genetic competence and behavioural competence should become the twin pillars of any long-term animal management strategy. Since 1974, zoos have supported an increasingly sophisticated global database, the International Species Inventory System or ISIS, which is now know as Species360, to minimize inbreeding of zoo stock.[12] The goal is to maintain a safe level of **genetic competence** for zoo animals over many future generations. This is admirable work with strong financial and intellectual support from the international zoo community. But what good is genetic competence to an animal which has become neurotic, physically weak and perhaps non-reproductive from inactivity and learned helplessness in limiting, unchallenging physical and social environments? The goal of environmental enrichment should not only be to improve the wellbeing of individual animals, but also to insure their natural **behavioural competence** for generations far into the future. Thus, environmental enrichment in the broad sense should receive international support equal to that received by genetic management programmes.

Enrichment planning checklist.

- Understand the dimensions of behavioural competence and needs of wild individuals and groups from long-term field research, including development of metrics transferable to captive situations.
- Create long-term enrichment programs designed to develop and maintain equivalent levels of behavioural competence based upon reliable evaluation systems.
- This does not mean the enrichment programs must use only “natural’ features, but rather that features maintain comparable degrees of investigative and challenge-meeting abilities in the enrichment programs. This does mean, however, that animals destined for release should have greater exposure to conditions and challenges they are likely to encounter in the wild.
- Determine what natural behaviours you hope to stimulate: type, frequency, circumstance, individual or social, etc.
- Determine what benefits are desired and how they can be measured and proven? Examples: improved strength, balance and coordination, species typical wild activity levels, reduction in stereotypic behaviours, etc.

[12] https://www.species360.org/

- Select the type of stimulus: olfactory, auditory, tactile, food, taste, novelty, interactivity etc.
- Consider the mechanical system and materials with which staff and/or animals will have contact: ingestion, toxicity, tooth damage, etc, as well as workability, animal and staff safety, availability, cost, maintenance, storage, support systems (example: computers, freezers, energy sources, etc), visual/thematic/educational aspect and such.
- Understand the species and individual animal: personality, experience, physical and mental fitness, etc.
- Understand the training and conditioning of staffs and animals related to introduction of novel objects and situations including enrichment features.

Exhibit size versus complexity and enrichment

Susan Wilson studied 43 groups of gorillas and 68 groups of orangutans in 41 zoological gardens in seven European countries to investigate activity level. She discovered that "…*factors important for gorillas were stationary and temporary objects, while movable objects were significant for orangutans. These findings suggest that objects within environments may be more important for captive apes than the size or construction of the enclosure"*[13](my emphasis). These findings demonstrate the need to align enrichment features to the needs of not only individual species, but also individual animals. But the author also sets up an all too common false dichotomy between exhibit size and enrichment features. This old debate over which is more enriching, larger spaces or more enrichment features, should have been laid to rest with Debra Fortham-Quick's 1984 admonition that both larger and more diverse areas and special enrichment features are essential for providing adequate housing for captive animals.

In my view:

- Larger empty spaces are better than small empty spaces.
- Larger, varied and complex spaces are better still.
- Larger, varied and complex spaces with multilayered enrichment features in both day and night quarters are far better still.
- Features should include fixed and mobile built-in features, fixed and mobile changeable features, staff activated features and animal activated features.

[13] Wilson, S. 1982

- Use the best combination of features to fit individual animal's needs, staff capabilities and realistic short and long-term expenses capabilities.

Enrichment: "Hardware"

Temporary enrichment features (may also be considered keeper-activated features): These create the experience of novelty and complexity for the animals. These are generally supplied, distributed or installed by zoo staff. They include a very wide range of items now usually included in enrichment programs globally. The designer's job is to provide convenient, safe staff access and sometimes to provide storage, washing facilities and electric power as needed. In a few cases, designers may develop plans for features like mobile feeding devices or animal activated light shows which may be rotated on and off use. Generally, but not always, temporary features are easily replaceable and thus inexpensive to acquire, but are a recurrent cost over time.

Passive built-in enrichment features: These are generally permanent or infrequently replaceable and are a part of original facility design and construction or major renovation. Permanent features can include hills, artificial geologic features or platforms for elevated viewing, sleeping and play, streams, cascades and pools, underwater jets or temperature gradients, trees and other shade and shelter structures, poles for climbing or provisioning food and such. These are often large and costly constructions. To justify this expense, large build-in features should provide enrichment opportunities the animals will use daily and never become bored with, for example elevated areas for basking and oversight, "hot rocks" and "cool rocks" (artificial geology or logs with built in heating or cooling mechanisms), pools or waterfalls for bathing and such. Although not commonly thought of in this way, raceways between areas enable animals to visit a variety of enclosures and could also be considered built-in enrichment devices (see animal trail systems below).

Active enrichment features: Built-in enrichment features such as feeding devices (which can also deliver other items for sensory stimulation) are usually staff activated. These tend to be expensive to design, build or buy and maintain and are thus relatively expensive.

Animal activated features: Having zoo staff and volunteers doing nice things for zoo, sanctuary and aquarium animals is desirable, but does little for the animal's need to express choice and control or build competence. Early attempts by Dr Markowitz and his followers to produce low cost and easily maintained enrichment gadgets such as automatic food dispensers or puzzle games often failed because of maintenance requirements. However, modern, easily available micro-electronics are providing new opportunities. Here are examples:

- As early as 1994[14], I suggested laboratory animals, with a little training, could be able to control indoor ambient conditions such as light levels and spectra, ventilation, temperature and humidity in their individual areas simply by positioning themselves in the vicinity of low cost electronic motion detectors. Aquatic animals and species such as tapirs, tigers and bears which enjoy bathing and water play can use the same devices to activate powerful underwater jets or air bubble curtains for their exercise and amusement.

- Most captive animals have implanted microchip radio-frequency identification (RFID) implants. The food animal industry has long used feedlot systems where individual cattle are recognised by RFID tags and given specific feed mixtures. Present practice even uses these systems to identify sick animals[15].

- Dr. Julia Hoy has developed small animal operated feeding devices and "smart gates" which allow pre-programmed access to selected animals.[16] A number of RFID triggered feeding devices could be hidden around a large enclosure with each programmed to open only for a certain animal or species (example: beaver but not rats or selected waterfowl and not free-ranging waterfowl) and only after a pre-programmed or random time. The animals would need to check all locations fairly frequently, simulating a foraging or hunting behaviour. These "smart gates" could also enable animals to choose among optional raceway networks or enclosures.

- Philadelphia Zoo has developed an elaborate network of animal exploration trails (raceways) as both exhibits and enrichment features[17] and will be considering the use of RFID-activated smart gates to allow selected individual animals to have first priority to choose the trails they wish, rather than staff selecting trails for them. For example, on a Monday the tiger may choose its desired trail route and destination. Then the leopard may be able to take any trail segment it wants except the one occupied by the tiger. The order can be changed through the week or selected randomly (see later section on rotation and trail systems).
- Melbourne Zoo recently developed interactive computer activities in which orangutans can interact with projected light to change colour, intensity and pattern, in effect "drawing with light"[18]. This can be expanded to facilitate the apes playing with the lighting in visitor areas.

Enrichment "software": These are the control systems which operate the active "hardware" described above, as well as the zoo's overall enrichment, staff and animal training and monitoring and evaluation programs. While the topics of this

[14] Coe, Jon 1994
[15] http://farmtracktech.com/solutions/feedlot/
[16] Hoy, J. Personal communication. For more information contact j.hoy@uq.edu.au
[17] http://www.philadelphiazoo.org/Explore/Zoo360-Animal-Trails.htm
[18] Webber, S.

paper revolve around preparing designers to constructively engage in contributing to environmental enrichment programs, it is essential to understand the commonly used term “environmental enrichment”, as defined above, is an integrated part of a well developed master enrichment management program[19] including documented visions, goals and objectives, observations, human, material and financial resources, budgets, schedules, actions, training and conditioning of staff and animals, routines, evaluations and planned evolution. These programs must be fully integrated with all other zoo programs, both in the front-of-house and the back-of-house. Designers are a contributing part of this team. Providing safe and convenient staff access for daily animal training and enrichment activities, materials management and storage and for long-term renovation and replacement of exhibit features should be of particular importance to designers.

Moving beyond fixed animal areas

Animal rotation exhibits (sometimes called flex of alternating exhibits). *“Animal rotation” is an integrated management and facility design strategy which allows animals to move sequentially between two or more interconnected display and off-display areas for the purpose of increasing available space and behavioural opportunities for the animals. Resulting increases in appropriate animal behaviour and activity should improve visitor interest and satisfaction. Forms of rotation include single individual, single species group, multi-species individuals and multi-species groups. In traditional zoo displays, a given animal or group may live its entire life in a single display yard. In a rotation display, the animal may spend mornings in one yard and afternoons in a second yard. While the animal is in the second yard another animal or group inhabits the first yard. Think of this as a “time share” arrangement for zoo animals.*[20]

Many zoos and aquariums have mixed species exhibits where several or many species share the area concurrently. In rotation exhibits, animals share the same areas consecutively. In both cases, animals must be free from diseases which could be transferred to the other species using the areas. “Islands” and “Glacier Run” exhibits at Louisville Zoo are excellent examples as is “Big Cat Falls” at the Philadelphia Zoo. Most zoo animals rotate between day and night quarters and in this case, one or several additional areas are added to provide increased space and variety as enrichment. Thus far, observations suggest the scent and sight of predator and prey species of each other adds interest rather than stress.[21]

[19] See “Enrichment Planning”: http://www.enrichment.org/MiniWebs/About_EE/planning_chart.pdf
[20] Coe, j. 2004
[21] White, B. et al 2003

Animal trail systems.[22] Linear enclosed raceways have been used to interconnect day and night animal areas, but were rarely used as activity areas until recently. They are unique feature because they not only interconnect areas of interest to animals and visitors, but they can also follow interesting routes and provide venues for overlooking the activities of humans and other animals. Animals often linger along their way to observe their surroundings or browse adjacent vegetation. After the early success of long raceways interconnecting activity domes at The Centre for Great Apes in Florida[23], Philadelphia Zoo embarked on a campus wide animal trail network in 2009 (refer to Philly Zoo 360 reference above). The network currently has over 700m of trails with sizes varying in diameter and robustness to accommodate small primates (pygmy marmosets can travel up to 1000m round trip across the campus and back), great apes, big cats, small carnivores and ants, as well as domestic ponies, goats, and sheep. Children have separate elevated trails. Trail use is voluntary and animals are never forced or rushed. However, in order to be effective, both exploration trail systems and rotation exhibits require a high degree of staff and animal training. When developed in sufficient complexity, zoo trail networks can resemble wildlife trail systems as described by H. Hediger[24].

Another older but equally amazing trail system was developed at the US National Zoo in the 1990's. The approximately 140m long paired ropes located 12m in the air connect the Great Ape House with the "Think Tank" exhibit. This allows female orangutans (hence called the "O-Line"[25]) to consort with males at both ends. Recently, Zoo Guadalajara in Mexico built a higher (25m) and longer "O-line" and a lengthy overhead trail system for small primates.[26]

What went wrong?

Many seemingly exciting enrichment ideas are envisioned but never built. Others are installed but never used. Why not?

Designer limitations: Since this paper has been prepared for a conference on zoo design for environmental enrichment, let us start with limitations too often brought to the table by designers themselves.

- **Stakeholder Consideration.** In her talk to a 2004 predecessor of this conference, Dr. Melfi clearly stated *"... many modern and expensive zoo enclosures do not meet the needs of the animals as well as they do those of zoo visitors and staff. We believe that this is due to two reasons: first, that the visitor experience has become the overwhelming consideration in the design*

[22] Coe, J. 2014
[23] http://www.centerforgreatapes.org/
[24] Hediger, H. 1950, p 14
[25] https://www.youtube.com/watch?v=Dz_JwhkKkM8
[26] Rendón, L. 2015 Personal communication

process and secondly, that when animal needs are considered they tend to be based on tradition, assumption or perception, rather than sound scientific knowledge, and therefore may be inaccurate[27]*".* Good design but must serve all stakeholders adequately and equally.

- **Literature and Research.** Very few zoo design specialists are acquainted with the literature on wild and captive animal behaviour or environmental enrichment and must rely on outside experts or zoo and aquarium staffs to provide essential knowledge and insights from these fields. But if the design specialist doesn't know what they need to know, how is this information brought forward and evaluated? A good system of knowledge management is required. An approach to providing such a system is suggested in the final section of this paper.

- **Local Architect.** While zoos in North America, Singapore, Australia and New Zealand tend to use national and international zoo design specialists and the number of these specialists is growing in Northern Europe, most of the world's zoos rely on local architects and engineers with no practical experience in this field. In some cases, architects are selected by city government sponsored design competitions in which the recipient zoo has little choice.[28] In this case, there is a heavy burden placed on the zoo to properly inform and educate the designers. This requires local zoo staff to have proper allocations of time, personnel and other resources to provide this essential preparatory service.

- **Design Style.** Most designers are well schooled in whatever design style is ascendant at the time, but may be blind to, disdainful of or even resist other approaches which may be best for zoo staff and educational programs and for the animal whose welfare they are responsible for. For example, I have seen architects spend their budget on centrepiece buildings when simple, functional and hidden buildings may have been best for their zoo clients.

Budgetary obstacles: Julia Hoy interviewed staffs from 30 zoos in Australia, Europe and the US and found cost constraints mentioned more often by enrichment staff than by managers.[29] Perhaps this happens when enrichment features are thought of in isolation rather than an integrated part of an overall redevelopment initiative. Failure to correctly assess long-term operating and repair costs can also result in unused features.

Technology limitations: Some enrichment features require an unavailable level of technical knowhow and complex features may be selected while much simpler approaches using off-the-shelf items may be overlooked.

[27] Malfi, V., *et al* 2004
[28] Fiby, M. 2009 Personal communication
[29] Hoy, J. 2009

Staff limitations: These come in several types:

- **Understaffing.** Facilities may be understaffed for work beyond basic animal maintenance. This is commonly true in countries where zoo husbandry remains rudimentary, but also may occur when growth in blockbuster exhibits outstrips operational budget capacity. In this case, it can be argued that if zoos cannot provide suitable environmental enrichment to all animals, they are failing in their duty of care for the animals they are responsible for.
- **Skills.** Limited staff skills can be overcome by hiring outside specialists to undertake ongoing training programs in both enrichment and animal training for husbandry and desensitization. Sometimes, an outside behavioural specialist is needed to help a problem animal improve, but these sessions should always include staff training as well.
- **Jurisdiction.** Sometimes union/management disputes prevent zoo staff and volunteers from undertaking enrichment while animals suffer.
- **Wild Behaviour.** Often animal care staff may know a good deal about traditional zoo or aquarium management practices, but know little about how the same species live in the wild. I've designed several elephant displays with large pools only to have care staff complain they are a waste of money because the elephants never enter them. It had not occurred to these elephant keepers that wild elephant youngsters are taught to use water bodies by their mothers and aunts and that keepers had neglected their caregiver duty to teach the zoo elephants natural activities like bathing.
- **Evaluations.** Few new zoo facilities are well evaluated after opening and even fewer are studied over time by independent researchers. So, how do we know if our objectives are being met and how to improve in the future? This also speaks to Melfi's earlier observation that design decisions need to be made on solid science and not tradition or assumption. Two exceptions are Louisville Zoo's five-year behavioural study of their Island (animal rotation) exhibit[30] and Philadelphia Zoo's support of a full time on-staff behavioural evaluator for their animal discovery trail system.[31] Melbourne Zoo is also undertaking both baseline and post-occupancy evaluations of new animal facilities.[32]

Philosophical limitations: These also can be limitations if staffs are opposed to some aspects of environmental enrichment.

- **Hands-Off.** I've worked with staffs who say "...why can't the animals just be left alone" or "why must we always be doing things to them?" Of course, many

[30] White, B. et al 2003
[31] Baker, A. 2012 Personal communication
[32] Sherwen, S. 2017 Personal communication

enrichment supporters see enrichment activities as doing good things for animals and not too them.

- **Clutter.** Some zoo senior staffs and public complain that enrichment objects make the exhibit “look like a junkyard”. Unfortunately, this often results in a contest for or against enrichment rather than a sensible search for suitable alternatives. Zoos should provide more natural or hidden enrichment objects and features in exhibit areas intended to realistically recreate natural habitats and continue to use “interesting junk” in off-display areas. Many newer zoo displays feature recreations of cultural settings such as villages or research camps. In this case, enrichment features themed along the same lines are appropriate. In more highly stylized or abstracted exhibit designs themed or more artificial looking enrichment features are appropriate.
  The fact that popular and proven enrichment toys are easily available in pet stores is not sufficient reason to use them in areas where they contradict the approved exhibit themes and appropriate creative alternatives are available. Enrichment activities have an essential role in communicating the zoo’s or aquarium’s “message” and must be designed to support that message while also supporting improved animal wellbeing.

- **Unnatural elements.** Are contemporary enrichment features too unnatural? Soon after the highly naturalistic “landscape immersion” exhibits were developed[33] Markowitz’s artificial enrichment features were criticized as unnatural and unnecessary.[34] But Forthman-Quick[35] showed that both large complex habitats and active enrichment are needed to optimise animal wellbeing.
  I simply add that where the intended exhibit is about conserving nature or simulating *in situ* wildlife experiences, it only makes sense to uses naturalistic or hidden enrichment features to elicit natural behaviours. However, in exhibits like the US National Zoo’s “Think Tank” whose educational message is about exploring the nature of learning and intelligence, seeing great apes using computers in a building is sensible and consistent. But exhibit designers and operators must beware of mixed messages.

- **Training.** Well considered animal training and enrichment are two pathways to improved animal welfare. Indeed, some experts believe “training is enriching”,[36] but others disagree. They support environmental enrichment and believe training is important to husbandry management, but do not considering training as enriching itself because training does not necessarily provide animals with control and choice.[37]

[33] Jones, G. et al, 1976
[34] Hutchins, M., et al 1984
[35] Forthman-Quick 1984
[36] Laule, G., Desmond, T., 1998.
[37] Malfi, V., 2014

I have personally seen numerous examples where animals seemed to look forward to and enjoy training sessions. These appear to be highly enriching on several levels to both animal and trainer, including building trust and rapport. If training or any other intended enrichment activity satisfies several but not all of the "five new freedoms" suggested earlier it deserves support.

Physical and operational limitations. Initially, enrichment programs were seen as remedial improvements to inadequate enclosures and animal care programs in older exhibits. These old facilities often made safe staff access and materials storage difficult to provide. However, in new purpose-built facilities, both staffs and designers must ensure safe and convenient short and long-term access and functional storage, cleaning and other special enrichment needs such as large-scale refrigeration and freezing facilities.

"Develop an animal welfare charter for your organisation that reflects a clear commitment to animal welfare principles." [38]

Embedding environmental enrichment into the design of new zoo animal facilities. In January 2016, Melbourne Zoo began setting up their process[39] for developing a series of interconnect display and housing facility for predatory species to be called "Leopard Ridge" which included Sumatran tigers, snow leopards, coatimundi and Tasmanian devils. Project manager Richard Rowe, General Manager for Operations at Zoos Victoria, Australia was especially interested in finding ways to embed enrichment programs and features into the design process so that they could not easily be eliminated later in order to stay within budget. Here is an outline of the steps taken:

- Determine role of enrichment in the zoo's overall goals: *"For Zoos Victoria, conservation is our mission and achieving high standards of animal welfare underpins this mission."* [40] Enrichment underpins animal welfare and so supports the Zoo's goals.
- Enlist an interdisciplinary design team representing all major zoo stakeholders[41] together with professional consultants in zoo architecture, landscape architecture, learning and interpretation and project management. This working group answers to zoo senior management and board of directors. Stake holders considered for the Melbourne Zoo project include:
    - Zoo Animals

[38] World Zoo and Aquarium Animal Welfare Strategy. p. 18
[39] Coe, J. Rowe, R., Sherwen, S. 2017. Presented at this conference.
[40] Sherwen, S. 2017, Personal communication
[41] Kelling, N., et al 2014 has much more useful information about selecting and working with user groups

- Zoo Staff & Volunteers
- Zoo Visitors
- Zoo Plants
- Free Ranging Zoo Animals
- Zoo Business Enterprise

- Project initiation meeting. Orient the group in the following areas:
  - Project need, background and business case, required project timeline and budget
  - Latest thinking and models for zoo animal welfare and enrichment
  - Roles and responsibilities of all players
  - Draft project goals. One included: *"Exhibits will result in a high degree of broad and deep team engagement and enrichment outcomes will reflect the passion, enthusiasm and aspirations at the beginning of project"*[42]

- Develop an Exhibit Design Charter[43] or "Bill of Rights" for all stakeholders with the team. A key understanding is that each of the groups should benefit from the planned improvements. For example, outstanding zoo animal enrichment opportunities would not only benefit those animals, but also increase satisfaction for zoo staff and visitors thus benefitting the zoo's attendance-based revenue, increasing the zoo's ability to care for its plants and free ranging animals.

- A novel assumption of this approach is that all players, including animals and even plants, are actually co-workers collaborating for mutual as well as individual benefit**,** thus a wider zoo workplace ecosystem. As Kelling *et al* suggest*: "Although some may still carry classic viewpoints of staff as caretakers, visitors as passive viewers and animals as property, the more advantageous viewpoint, especially for design purposes, is to define these three groups as co-workers allowing for the organization of their interdependent relationships. However, this redefinition would require accepting the notion that animals are performing work rather than simply existing within the structure. In our reclassification of animals as co-workers, animal jobs may be as simple as remaining healthy and active in order to engage and educate visitors by performing species typical behaviours or as complex as reproducing to sustain the species."* [44] Even the concept of providing zoo and aquarium animals with occupation as enrichment[45] seems to fit into this model.

[42] Rowe, R. 2017, Personal communication
[43] For more on this approach see: Choquette, W., 1994.
[44] Kelling, N., et al 2014, p. 339
[45] Yerkes, R., 1925 idea of "work and play" as enrichment in Young, R., 2003 p.9

- Develop an Animal Enrichment Framework[46] from the charter comparing known species-typical physical and behavioural needs and individual animal personalities. Types of enrichment included:
    - Passive Enrichment (physical exhibit elements)
    - Active Enrichment (staff activated elements)
    - Animal Activated Enrichment (includes on-display and off-display animal areas)

- Question each type of enrichment:
    - What do we want to do?
    - What do we already have and can do?
    - What resources are needed?
    - Animal conditioning needs?
    - Keeper training needs?

- Determine how existing animals use their present enclosures? These baseline studies are essential during the preparation of later before and after project evaluations.
    - Current measured flight distance from visitors and from zoo staff
    - Evaluation of present forms of enrichment
    - Personality profiles developed for individual animals
    - Ethograms of present enclosure use by animals should be included

- Benchmark and brainstorm to develop specific conceptual enrichment ideas. These were considered from the following viewpoints:
    - Veterinary: risk of injury, sanitation concerns (zoo's animal risk management policies)
    - Ease and safety of daily maintenance and access
    - Staffing requirements
    - Durability and replacement concerns
    - Feasibility of procurement or in-house construction
    - Impact on public
    - Support of learning objectives
    - Support of animal welfare objects
    - Support of conservation objectives
    - Support of revenue generation objectives

- Preliminary design integration. Select enrichment ideas were integrated into evolving project preliminary designs based upon:
    - Special site opportunities such as existing waterfalls, sun angles, public viewing areas and distances, staff access and such
    - Theme areas, for example some areas were well suited for highly realistic nature-like treatment based upon existing vegetation and

[46] Zoos Victoria, 2016, Predator 2 Enrichment Framework

artificial rock work while other areas were more suited for displays utilizing clearly constructed artificial animal habitats
    - Preliminary project cost analysis resulted in the overall project funds being rebalanced among all categories without losing favoured enrichment features

- Detailed design integration includes further design development and ongoing design team review and refinement:
    - Staff develop specific operational requirements including staffing hours, skills, additional training and associated costs
    - Plans are made for temporary relocation of animals for construction period
    - Untested enrichment features are prototyped by zoo craft workers or speciality contractors and field tested by zoo staff and animals
    - Detailed cost estimates (quantity surveys) are developed and again all project costs are brought within budget and timeline without compromising integrated enrichment features

- Construction and tender documents. This repeats the above step, but in more detail. This includes determination of work to be undertaken by zoo staff and work to be tendered to independent builders. Further prototyping is undertaken and again project costs, budget and schedule are brought into balance and necessary cutbacks are shared among all stakeholders.

- During construction, the zoo team monitors progress to insure original objectives are being met.

- After opening, monitor and evaluate the project for quantifiable improvements in animal welfare and fitness as compared to previous levels.

- The integrated exhibit planning and design process will be evaluated for achievement of initial goals and for lessons learned.

The designer's role in environmental enrichment.

I have used the term "designer" for everyone given responsibility for developing the zoo, aquarium or sanctuary facility's size, characteristics, functions, contents, quality and cost. I do not assume this term applies only to professionally trained designers. Everyone on the interdisciplinary design team who has earned "a seat at the table" to represent their unique knowledge and expertise in fields as varied as horticulture, animal care, informal learning, plumbing and multimedia has an essential role to play in concert with the professional design team. This part of the process is not new, but remains essential, both to harvest the combined knowledge, diversity and experience of the group, but also to enlist their support for the completed works and

ongoing enrichment and other management and display programs they helped to develop.

A new approach to project development suggested here is the deployment of the highly successful "partnering" and "charter making" approaches used in conflict management, or more properly, in conflict avoidance project management strategies.[47] In the Zoos Victoria example, the early development of a "Bill of Rights Charter" for all stakeholders helped established a common approach that enrichment is not just something good for animals, but also benefits staff, volunteers, visitors and the zoo's bottom line.

Thus, enrichment features and operating programs are much more than dispensable, non-essential add-ons. To quote David Shepherdson, "*Environmental enrichment has become the primary de facto tool for addressing psychological well being in zoo and aquarium animals"*[48]*,* and I would add assuring both daily physical fitness and behavioural resilience and long-term behavioural competence. At Zoos Victoria enrichment is essential to animal wellbeing, which underpins their entire conservation strategy. Thus, it is time to move beyond the minimal "Old Five Freedoms" for animal welfare and to engage, develop and activate the "New Five Freedoms", increasing the opportunity not only for animals, but for all stake holders to "Achieve Competence, Have Choice, Take Control, Experience Variety and Engage Complexity".

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