

Outdoor Science Parks

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Abstract

The importance of Outdoor Science Parks that highlight Science and Technology through hands-on interactive exhibits has recently grown, as more Science Centers throughout the world are implementing them. The motivation for developing Outdoor Science Parks is presented. The significance of being outdoors and the choice of themes and exhibit ideas suited for the outdoors are discussed. Exhibits that use natural elements in their operation and foster innovation and inventiveness among the younger generation are highlighted. Since Outdoor Science Parks do not require buildings, their implementation may be speedy and economical. Several Outdoor Science Parks that the Author designed and built are highlighted; the Weizmann Institute of Science's Clore Garden of Science; the Israel National Science Museum's Noble Energy Science Park in Israel; and SciTech Hands On Museum's Outdoor Science Park in the USA.

Introduction

Imagine a child standing on a platform, with the sun behind her back, using a water canon to spin a turbine, observing the spectacular colors of a rainbow, touching the water drops and wetting her hair. Nearby, three of her friends are tugging ropes and hoisting their parents who are seated on the Giant Lever. Meanwhile another child is drumming away on the Lithophone, a marble percussion instrument, composing his own melody. The girl then moves on to experience High Wire Bicycle riding. And for a tasty snack, the group gathers to cook marshmallows on the Solar Furnace. Being outdoors provides inquisitive and curious minds the opportunity of experiencing science in a natural laboratory, where they are free to use the available resources of the sun, wind and other elements.

With the high costs of constructing buildings, professionals in the science center field may be interested in knowing more about expanding their exhibits and audiences through Outdoor Science Parks. How to emulate the best in Outdoor Science Parks, capitalizing on the natural elements, may be useful information. Many more Science Centers throughout the world are currently designing and implementing Outdoor Science Parks to foster innovation and inventiveness among the younger generation. This paper examines the concept of Outdoor Science Parks, the learning opportunities they provide, and the added benefits of exploration in a natural outdoor environment. Several Outdoor Science Parks that the Author designed and built are highlighted: the Weizmann Institute of Science's Clore Garden of Science; the Israel National Science Museum's Noble Energy Science Park; both in Israel and SciTech Hands On Museum's Outdoor Science Park in the USA. Other Outdoor Science Parks may be e-visited through references 1-5.

On the Significance of Being Outdoors

Being outdoors provides an unusual amount of space for exhibits and a great deal of flexibility in their arrangement. The outdoor setting facilitates the use of natural resources in exhibits and educational programs. Visitors are able to see, feel and use the resources of the sun, water and wind. They experience some of the scientific phenomena that surround us using the Outdoor Science Park's natural laboratory and see that science can be learned in many locations, not only in classrooms and indoor laboratories.

Placing Hands-On exhibits in an outdoor setting, distinguishes Outdoor Science Parks from indoor Science Centers. The Outdoor Science Parks take into account the size, as well as requirements of sun, shade, water and wind use of the exhibits. Outdoor Science Parks are designed with attractive landscaping and environmental approach, thereby fostering awareness and understanding of the value of our environment.

While Outdoor Science Parks provide an economic incentive by saving the cost of constructing or renovating a building, other physical aspects are to be considered. These include daily and seasonal temperature changes, moisture, sunlight, wind and air quality. These aspects necessitate the building of exhibits using very durable materials and in some climates can limit their usage time.

Choice of Themes and Exhibits Suitable for the Outdoors

Themes that are most suitable for the outdoors include Water, Environment, Solar, Wind, Waves, Music, Motion and Space exhibits. Exhibits on the same theme are grouped together, to enable learning of the theme in a localized area.

The possibilities of using **Water** to demonstrate scientific phenomena are especially suited to an outdoor environment. Water exhibits can have fast or slow flow. Some examples may include

- Water Canons – water jets that turn Water Vanes or small Turbines;
- Water Turbines – use water energy to turn a large turbine;
- Archemedes Screw – to raise water from a pond;
- Wave Pools – used to create waves;
- Water Dams – used to direct water flow;
- Ecological Ponds – used to highlight water fauna and flora;
- Rainbows – used to generate full circle rainbows;
- Water Vortex – used to generate vortices in water.

The theme of **Environment and Recycling** is important for young visitors, raising awareness and encouraging implementation throughout their daily life. Examples may include

- Water Purification System – using the exhibits' water system;
- Meteorological Station – to measure weather conditions;
- Recycling Separators – to let visitors separate paper, plastic, metal and glass;
- Landfill Models – to observe and experiment.

Solar Exhibits make direct use of the sun's energy and showcase alternative energy sources. Exhibits may include

- Heat Tunnel – where visitors crawl through a half white half black large diameter pipe;
- Solar Furnace – a parabolic mirror concentrating the Sun's rays to its focal point;
- Solar Water Heater – to demonstrate alternative energy source;
- Photo Voltaic Cells - to demonstrate alternative energy source;

- Solar Fountain – height of the water jet is proportional to the Solar radiation.
- A special place in the outdoors is devoted to **Sundials** which measure solar time. By observing Sundials visitors learn the difference between solar and average time, about the seasons and about the Earth's rotation and revolution around the Sun.

Wind - Another alternative energy source and an excellent way to utilize outdoor resources is the Wind. Wind Exhibits may include

- Wind Turbine – transferring the Wind's energy;
- Windmill Seat – raising and lowering the visitor;
- Wind and Weather Vanes – showing the direction and speed of the wind.

Waves and Communications. Sound, Light, Weather and many scientific phenomena are transferred by waves. The advances in Information Technology are especially relevant in the emerging knowledge-based economy. Exhibits may include

- Tall Wave Generator – a torsion wave demonstrating the formation of waves;
- Sound Pipe – transfer of Sound inside a 110m long pipe, creating a delay of 1/3 second;
- Pan Pipes – differing length pipes creating different pitch sounds;
- Echo Tube – a long pipe sealed at one end that reflects sounds;
- Acoustic Mirrors – two parabolic mirrors facing each other that are used for wireless communications.

Music - It is refreshing to listen to Music produced in an outdoor park setting, where the sound level is kept pleasant by the space and the vegetation. Exhibits may include

- Lithophone - a marble percussion instrument;
- Glass percussion instruments – made of thick glass;
- Musical Rocks – different cuts through a strong (lava) rock create percussion pillars;
- Metal Drums – traditional or modern designs.

Motion - The theme of Motion demonstrates mechanical phenomena in an interactive approach. Exhibits may include

- Giant Lever – demonstrating leverage ratios and fulcrum point;
- Slides – straight, cycloid and other shaped slides;
- YouYo – an inverted yoyo, where the visitor is raised;
- Gyro Wheel – demonstrating the forces of a gyroscope;
- Pulley System – demonstrating leverage ratios;
- Coupled Swings – used to transfer energy between two coupled systems;
- Coriolis Carousel – transfer a ball across a spinning carousel;
- SeeSaws – various ratios can be compared;
- Inertial Trajectories – test the acceleration of different bodies;
- Galilean, Resonant, Five Ball and Chaotic Pendulums.

Space Exploration - What would we feel like in our own atmosphere, on the moon or on other planets? Space Exploration exhibits may include

- Telescopes – refracting and reflecting telescopes with an open design;
- Bernoulli Exhibits – blowers, balls and wings;
- Moon and Jupiter Gravity Swings – simulating how we might swing in their gravity;
- Lunar Simulator – simulating 1/6 gravity field of the Moon;
- Planetary Scales – what your weight would be on different planets;
- Scale Model of the Solar System.

The Clore Garden of Science, Weizmann Institute of Science, Rehovot, Israel

The Weizmann Institute of Science is a research institute studying topics at the forefront of Life Sciences, Chemistry, Physics and Mathematics. The Clore Garden of Science is self-contained Outdoor Science Park enjoying the campus garden environment, and cooperation with its international body of research staff. Established in 1998, while the author was its Scientific Director, this Outdoor Science Park was designed to exhibit exciting scientific principles and to involve the visitors in ongoing research topics. See Figure 1 and Ref 6.

The 10,000 m² (two-acre) site is complemented by a youth dormitory for students from Israel and abroad, expanded teaching laboratories, enclosed demonstration areas, and a public cafeteria.

The Garden is composed of eight themed “Courts of Wonder” - Water, Motion, Waves & Sound, Planetary Sciences, Energy & Environment, Music, Life Sciences and the Kinder-Court. The eight courts were selected for their scientific and aesthetic appeal, their suitability to the outdoor setting, use of natural elements and suitability for the open space environments. Visitors enter the garden through a circular plaza leading to a wide axial path devoted to The Court of Water. Changes in elevation, enhanced by trees and paths, separate the courts while unifying the Garden into a harmonious whole. An elevated deck spans the Garden, enabling a panoramic view as well as providing a setting for several exhibits. Some of the courts are described below, with a few detailed examples.

Water is a fascinating medium for observing natural phenomena, demonstrated by some special exhibits in the “Court of Water”. Why do some things float and others sink? What do whirlpools and tornadoes have in common? If you spin a body of water, what shape does it take? How can we get water to do work for us? A highly visual exhibit in this court is the Wave Channel, which allows visitors to create waves that simulate the lake, river and ocean. The exhibit is a long (25 m) water channel leading to a curved shore. A wave generator is mounted at the beginning of the channel. Visitors observe the waves created and may make their own experiments using boats.



Figure 1: Dinosaurs invade The Clore Garden of Science, Weizmann Institute of Science, Rehovot, Israel

The “Court of Energy and Environment” consists of exhibits that demonstrate nature’s balance, and how we can use virtually non-depletable energy to do work for us. Of special interest are solar energy exhibits like the Solar Fountain where the height of the fountain is proportional to the energy collected. The Solar Tower obtains its energy from an array of six mirrors pointed to a common focal point by the visitors, just like the large Solar Tower research facility of the Weizmann Institute which consists of 64 huge mirrors. In a refreshing corner within this court are two ecological pools, where we observe life forms living in harmony with their environment. The visitors raise water from a pool by running inside a large Archimedian screw. In the Flowforms exhibit water is pumped to create circular whirlpools in cascades.

The “Court of Music” is one of the most popular attractions. The participants create sounds by striking natural objects that resonate to create music. Among others, its exhibits include a Lithophone, Musical Rocks fashioned of lava and a large Echo Rock. Visitors happily play popular melodies which are heard all over the garden.

Yet another very popular attraction is in the “Court of Planetary Sciences” - the TrampoLuna. Only a very few people have walked on the moon, while the rest of us have to be content with imagining what it would feel like to move about with all our muscle capacity, but only weighing one-sixth as much. In the TrampoLuna exhibit in the Court of Planetary Sciences, the participants experience the near-weightlessness of walking on the moon. They are strapped into a harness at the end of a cable. With the cable taking almost all the participant's weight, they can propel themselves by bouncing about the perimeter of cone-shaped barrel wall.

The Kinder-Court encourages younger children (3-6 years of age) to safely explore everyday principles of our natural world through exhibits that are top-heavy with active fun. Elementary applications of such phenomena as the Lever, mathematical puzzles, constructing and climbing on a Catenary Bridge help provide learning opportunities for the younger age group.

Israel National Science Museum Noble Energy Science Park

The Israel National Science Museum is dedicated to preserving, popularizing and promoting the rich cultural heritage of science and fostering a love of science and technology among Israeli children and adults. The Noble Energy Science Park is concrete evidence that this important mission can be accomplished.

Established in 2011, while the author held the position of General Director, this one acre park sprawls over the outdoor area between the historical Exhibitions and Education buildings and complements the indoor scientific experience. See Figure 2.



Figure 2: The Noble Energy Science Park, Leonardo da Vinci Court, Israel National Science Museum, Haifa, Israel

Through captivating large interactive exhibits, the Park renders tangible, the scientific principles underlying the discoveries of a number of giants whose breakthroughs shaped the course of science. Each of the Park's thematic courtyards focuses on the discovery of a noted scientist--Archimedes, Leonardo Da Vinci, Sir Isaac Newton, Daniel Bernoulli, Galileo Galilei and Pythagoras. It also provides the cultural contexts in which these remarkable scientists worked--while depicting them as people who led ordinary lives, with which we can all identify. An open-air expansive amphitheater is located in the midst of the park. It seats 400 people and overlooks a compass rose shaped fountain, with fascinating adjustable water and color features.

For visitors, the Science Park is a green lung in the midst of the city; a getaway where they can gain first-hand fun experience of key science and technological principles that shape the world we live in and discover that science is present in every aspect of our lives, not only in schools and science institutions.

SciTech Hands On Museum Outdoor Science Park

We now move to the US where there is a strong interest in developing Outdoor Science Parks. **SciTech Hands On Museum** was established by scientists from Fermi National Accelerator Laboratory and Argonne National Laboratory. The major indoor exhibit areas, with over 250 hands-in exhibits, are the Solar Telescope (displaying a 3-ft diameter live image of the Sun), Modern Physics, Magnets and Electricity, Mathematics and Structures, Sport Science, Motion, Wild Weather, Sound and Music, Light and New Technologies, Optical Illusions and Astrophysics.

Established in 2000, while the author held the position of Executive Director, SciTech's **Outdoor Science Park** is located at the southern tip of Stolp Island. The two branches of the Fox River meet just beyond the Center, creating a scenic area attracting many visitors. See Figure 3.

SciTech's implementation of the Outdoor Science Park enhances and complements the visitor's learning experience at the existing indoor facility. Visitors to the Outdoor Science Park explore topics of Water, Motion, Waves and Sound, Energy, Environment and Music. The interactive outdoor exhibits use the resources of the sun, wind and water to provide stimulating hands-on environment. By increasing the Outdoor exhibit and educational program space, SciTech is able to develop and effectively run more programs throughout the entire year, thus expanding its audience.

The Outdoor Science Park currently includes fifteen interactive outdoor exhibits, and its surface is landscaped with flowers, planters, picnic tables and sun shades. The Outdoor Science Park was inspired by the Clore Garden of Science at the Weizmann Institute in Israel. The size of the Outdoor Science Park is 500 m². The Outdoor Science Park is funded in part by the Illinois Public Museum Program, Illinois First, the National Science Foundation and by in-kind contributions. The Outdoor Science Park was dedicated in October 2000.



Figure 3: SciTech Hands-On Museum Outdoor Science Park on the Fox River, Aurora IL
USA

The most visible exhibit at the Outdoor Science Park is the 14m tall Weather Wave, where visitors create their own standing waves. At the top of the structure two aesthetic Wind Vanes are placed to demonstrate the wind's strength and direction. The weather wave is a modified version of Chanan De Lange design at the Clore Garden of Science.

One of the most popular exhibits at the Outdoor Science Park is the Giant Lever. Several people sit on a ski lift type bench which hangs at the end of a long (10m) pole. The pole rests on a fulcrum point with a ratio of 1:3. Other visitors are able to lift the bench by pulling on chains with a ratio of 1:1, 1:2 and 1:3 thereby demonstrating the lever effect.

Everyone who rides the Bicycle on a Tightrope gets a first foot (first hand) visualization of the concept of Center of Gravity. As visitors ride the bicycle across a tight cable, a suspended weight keeps them and the bike stable.

The YouYo is an oversized inverted yoyo. The flywheel representing the yoyo is mounted at the top of the exhibit. The visitors pull the rope propelling themselves higher and higher with every turn of the wheel. The YouYo is an original invention of Jonathan Engineering [9], who also designed and produced most of the oversize exhibits at the Outdoor Science Park.

The Coupled Swing is a demonstration of Coupled Pendulums. But instead of having two identical coupled swings, there is only one swing coupled to a 150 kg weight. Since only one visitor uses the swing, this may reduce confusion in its operation. The exhibit demonstrates coupled pendulums and the energy transfer between them.

The Lithophone is a Marble percussion instrument that looks like a Xylophone. It has a range of one full octave. The acoustic properties of the marble produce a clear resonating sound. The visitors play their melodies all day long.

Maintenance and Safety of Outdoor Exhibits

Outdoor exhibits that are exposed to the elements need at least as much maintenance as indoor ones. The Outdoor exhibits need to be robust and made of durable materials to withstand the elements and the visitors' interactions. Metals should be non-corrosive, Aluminum or Stainless Steel. Maintenance topics are similar but more demanding than outdoor playground equipment, as there are many more moving parts.

Interactive Outdoor Exhibits require careful attention to Safety issues. Every year over 150,000 people are injured in outdoor playgrounds in the US. Most injuries (75%) are due to falls and the rest due to injuries resulting from sharp corners or from moving parts. Since there are no codes for outdoor interactive exhibits, the codes for Playground Equipment are usually used. When designing the outdoor exhibits described in this paper appropriate US, European or Israeli safety codes were used.

To ensure the safety of the visitors and the exhibits it is important that the Outdoor Science Park be fenced and has controlled access. When visitors are using the exhibits trained staff members must be on hand to ensure their safety. In addition staff members

should be placed near exhibits that require their assistance. A minimum age for users needs to be designated.

Visitor Experience and Evaluation

The visitors' responses to the Clore Garden of Science and SciTech's Outdoor Science Park have been very favorable. School groups and families interact enthusiastically with the exhibits, and report positive experiences. The Outdoor environment complements the indoor experiences, allowing visitors more freedom to interact with the large Outdoor exhibits that use a high tech design. By exposing the visitors to Outdoor Science Parks as an annex to traditional science centers, one may foster technology awareness in the Outdoor Science Park's unique context. The media has been attracted to these new projects, as the extra large outdoor exhibits are highly visual. Many articles appear in the press, giving the museums positive publicity.

There is a need for more formal evaluation to be performed about the effectiveness of the Outdoor Science Parks presented. A visitor-centered process with front-end research to assess what the public knows and is interested in knowing would assist in the themes selection. Summative evaluation would help to determine changes in visitors' attitudes or understanding.

Conclusions

The importance of Outdoor Science Parks that include hands-on interactive exhibits has recently grown. Outdoor exhibits that use natural elements in their operation may foster innovation and inventiveness among the younger generation. Since Outdoor Science Parks do not require buildings, their implementation may be speedy and economical. The time is ripe for science centers to provide their visitors with a natural outdoor laboratory. Outdoor exhibit areas add an extra dimension to indoor science Park, and provide a challenging experience that complements the indoor visit. Interactive outdoor exhibits that make use of natural elements are a great attraction and a special learning environment. The success of the Israel National Science Museum's Noble Energy Science Park, SciTech's Outdoor Science Park and the Weizmann Institute of Science's Clore Garden of Science, stems from special exhibits that are based on experiments. The exhibits use the resources of the sun,

wind, and water flow to provide a stimulating hands - and mud - on environment. Through outdoor participatory exhibits of scientific phenomena, one fulfills the natural curiosity to explore, and whets young appetites for more.

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