Designing for Children

- With focus on 'Play + Learn'

Hands-on Learning - The Agastya Experiment

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The author is a Mechanical Engineer by profession and is Technical Advisor and Design Team Head of the Agastya International Foundation. He has designed a host of interactive models, which are created to inspire the questioning instinct in children and communicate that learning can be fun. The curiosity ignited by the models helps the children and teachers understand the underlying scientific principles of the exhibit/experiment.

Abstract: The Agastya International Foundation, a Bangalore-based education trust, is the world's largest hands-on mobile science education program for disadvantaged children and teachers. Agastya seeks to transform and stimulate the thinking of rural children. Agastya does this by innovative programmes such as the "Science on Wheels" (Mobile van program) and science fairs. The vision is to build a creative India of 'tinkerers, solution-seekers and creators' that are 'humane, anchored and connected' by inspiring widespread social development, innovation and leadership through education. Agastya reaches nearly 1.5 million children annually through its 32 mobile labs, 14 rural science centres and a 175-acre creativity lab campus.

The Design process starts by the Design Team taking a look at the project from the child's perspective. If the model shows something that is out of the ordinary, something that is contrary to conventional logic, such an experience will succeed in drawing and holding the attention of the participating child. Once the child gets interested, the model can demonstrate and convey the operative science behind the unusual phenomenon in easy steps. The design process followed emphasizes the importance of fun, engagement and simplicity. Rapid prototyping allows quick rollout incorporating incremental design inputs.

Key Words: Interactive Design- child's perspective- creative learning- Discovery Centre - Mobile Labs

1. Introduction

Agastya International Foundation realised right at the beginning that most of the children in our schools, both rural and urban, have very little hands on experience with working models or experimental set-ups to understand the basics of science and how the basic principles are utilized in the development of various practical utilities and machines. Thus, Agastya started designing and creating interactive models to bring a clearer understanding of the basic scientific principles whilst educating children for the past eight to ten years. Our target audience is essentially rural children in the age group of eight to fifteen years. We have also demonstrated our exhibits in some urban schools and children from these schools have been visiting the Creativity Lab Centre and most of them expressed a desire to revisit the Centre for further studies and experimentation.

The basic principles that are followed in the design process are:

- The model should be interactive. Children should be able to operate the model with their own hands.
- The very first exposure to the model should arouse curiosity in the children so that their attention is captured. In other words, it should be “fun” to play with the model and to learn at the same time.
- It should be relatively easy to connect up the model’s function with the underlying scientific principle that is being explained.
- It should encourage teamwork, whenever possible.

We are trying to maximize our efforts to expose rural children to these models by means of a three pronged strategy.

- Visits to the Discovery Centre and Science Labs situated at our campus in Gudivanka
- Our uniquely designed Mobile Laboratories visiting rural schools
- Organising Science Fairs & Young Instructor Programs at different district centers

2. Agastya Discovery Centre

The Agastya project is set in 175 acres of undulating terrain in Gudivanka, Andhra Pradesh. Gudivanka is located at the intersection of three rapidly developing Southern states, Andhra Pradesh, Karnataka and Tamil Nadu. It is connected by road and rail to the cities of Bangalore and Chennai. It is situated 2,200 feet above sea level with a pleasantly invigorating weather all year round. Clean and refreshing air greets and rejuvenates the senses. A placid lake gives the location a picture postcard setting. However, it is a "backward" region and it is among the lowest rates of literacy in India.

Figure. 1 Agastya Discovery Centre

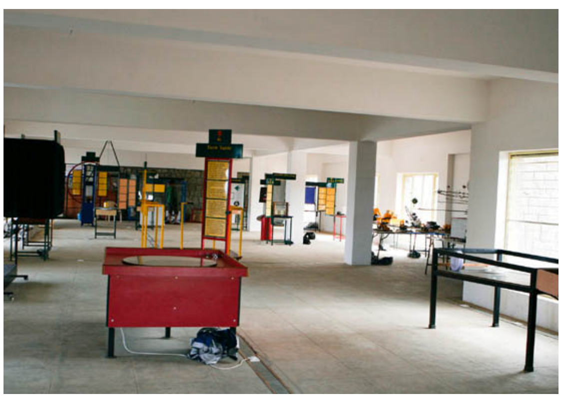

Figure. 2 An Interior View of Discovery Centre

The Discovery Centre (Figure.1) houses more than sixty interactive exhibits which are conveniently positioned in two spacious display areas. In addition, there are quite a few out-door exhibits also to give additional flavour to inspire students. In this presentation, a few exhibits have been selected to illustrate the special design features and the nature of interactivity of these models.

2.1 Hyperbolic Slot

Figure. 3 Hyperbolic Slot

It is necessary to expose the children to geometrical figures and axes of symmetry. With geometrical shapes such as cube, cone, sphere etc., one can demonstrate the various axes of symmetry, mirror planes etc. It is also of interest to know how the cut section of these objects would look like. It is equally interesting to know the intersection between a 3-D object with a two dimensional plane. Thus, the hyperbolic slot came into existence.

An inclined straight line rotating about a vertical axis forms a hyperboloid. When a vertical plane intersects the hyperboloid, a hyperbola is formed. By making a slot to follow this hyperbola, we make the inclined rod pass through the hyperbolic slot. The children start to wonder how a straight rod can pass through a curved path so easily.

2.2 Momentum Machine

Figure. 4 Momentum Machine

If you stand on the circular platform and try to spin by wiggling your body or legs, you would find it very difficult to start the rotation. However, if you push on the platform attached to the ground, then you rotate easily. You can increase or decrease your speed of rotation by changing the position of your legs and hands.

Angular momentum is the product of angular velocity and moment of inertia. Moment of inertia depends on both the mass of an object and how that mass is distributed. The farther the mass is located from the axis of rotation, the larger is the moment of inertia. Thus, moment of inertia is small when your arms are held at your sides but large when your arms/legs are extended straight out. When you put your leg out, you notice your angular velocity decreases. Likewise, the angular velocity becomes more when you bring your arm/leg close to your body. This demo explains how the ice skaters spin with ease at such high speeds and how they slow down and stop.

2.3 Coordination Crane

Figure. 5 Coordination Crane

This exhibit is to be handled by 2 to 4 players. Observe that there is a rocket in 3 parts that needs to be assembled. There are 4 pulleys and hooks in each one of the ropes that passes through the pulley. The job is to use the pulley system to place the 1st part in the centre of the table and then to assemble the other two parts on top of each stage so that the rocket is ready for firing. The team that finishes fastest gets the credit.

The players get some idea of resultant forces that is obtained when more than one force is applied.

2.4 Quadra-Cycle with square Wheels

Figure. 6 Square wheel Quadra-Cycle

Ride the Quadra-cycle on the track. Observe that the cycle moves smoothly on the profiled track in spite of having square wheels. If you try to ride a square wheeled cycle on a flat surface, you fail to do so because the center of gravity of the square wheel shifts to variable heights from the ground. The variable distances are compensated by placing the Quadra-cycle on a track consisting of multiple inverted catenaries. As the square wheel rolls over these bumps, its center of gravity is always over the point, where the square touches the bump. That is why when the wheel rolls over the center of gravity always remains at the same height from the ground level. When the cycle moves on the track, observe that the height of the wheel axle remains constant through out the traverse.

2.5 Bhishma's Chair

Figure. 7 Bhisma's chair

Figure. 8   Bhishma's Chair on trial

Check whether the aircushion below the pointed nails is inflated. Then slowly sit over the nails. Do you feel any discomfort? If not, why did you not feel any discomfort?

The air cushion adjusts to your contour and thereby increases the contact area with the nails. As the area of the nails on which your weight is resting is increased, the pressure that each nail exerts on your body gets reduced. Hence, you do not feel the prick. This is amplified further with the help of the balance and weights for you to check.

2.6   Short Sight and Long Sight

Figure. 9   Short Sight & Long Sight

In this exhibit you see an eye ball, a source of slits farther away and another that is nearer to the eye. Switch on the light source. On the left side you see the red slits in the retina in focus, but the image below that comes from the nearby object appears blurred. Now insert the lens provided in front of the eyeball. See the change in the image below.

Likewise, on the right side you see the image from a distant object is blurred, but the image formed by the nearer object is in focus. If you insert the lens provided, you see both the images become clear and are in good focus.

The above two conditions of human eye are called long sight and short sight. These are corrected by appropriate lenses as you have just seen in the demonstration. In the case of short sight, the eye lens focuses the image in front of the retina instead of on the retina. By interposing a concave lens before the eye lens, you make the image form on the retina. This leads to a clear image. In the case of a person with long sight, he sees the objects at a longer distance clearly, but not able to see the nearby objects clearly. This is because the eye lens leads to a focus beyond the retina. By placing a convex lens, you are able to shift the focus nearer so that the image is formed on the retina itself. Hence, the image is in focus. The power of the correcting lens is expressed as diopter, which is the reciprocal of the focal length of the lens in meters.

2.7 Soap Cylinder

Figure 10 Soap Cylinder

Get inside the enclosure and close the glass door to avoid draft of air. Stand in the middle of the circle and hold on to the top of the ring with both hands. Dip the bottom of the ring in the soap solution and slowly lift the ring up. See that a soap cylinder is around you.

A soap or detergent molecule consists of a long slender nonpolar hydrocarbon chain with a highly polar oxygen-rich group attached to one end. When such molecules are added to water, they tend to migrate to the surface and orient themselves so that the nonpolar ends are sticking out. The surface of the water is covered with a non-polar layer which drastically reduces the surface tension and adds stabilizing elastic properties to the liquid surface along with an increase in surface area. When a wire or plastic frame is placed into the solution and then withdrawn, the water tends to drain from the inside of the raised surface, making the surface begin to collapse on it forming a multilayered film.
The swirling colours observed in the bubble are a result of thin film interference and the changing thickness of the film due to the draining liquid.

3. Special Design Features in the above models

All the models are designed such that the children can operate them freely without any damage to the equipment or getting themselves hurt.

The Coordination Crane has been designed for team work. A minimum of two and a maximum of four children are needed to operate the crane successfully and assemble the rocket. This helps the children who tend to be generally competitive to learn to cooperate with their friends to achieve the end objective.

The cycle with square wheels goes strikingly against the normal experience of children who would have seen only circular wheels on a bicycle. This initial surprise can be harnessed to grab the child's attention. A ride on a Quadra-Cycle with Square Wheels makes the interactive experience even more intense. In fact it has been our experience that as soon as a group of school children enter the Discovery Centre they make a beeline to the Square Wheel Quadra Cycle and the Momentum Machine. After an exhilarating Quadra-cycle ride the children are ready to learn and appreciate the mathematics behind the rolling profile of the Wheel and the inverted Catenary of the track.

Introducing the name Bhisma in Bhisma's chair, immediately brings some feeling of familiarity in the child's mind as he or she would have been familiar with the legendary figure.

The soap cylinder is also very popular with the children mainly because of the fact that the child creates the soap screen with his or her own hands. To understand the colours that are created in the soap film, the children learn about constructive and destructive interference of waves.

We have observed that that the short sight and long sight model helps the children understand this optical phenomenon very graphically since the simulation has been designed to resemble the actual eye and spectacle situation.

In a similar way, an abstract concept like the formation of a hyperboloid by the sweep of an inclined straight line is brought home in a physical three dimensional manner.

Finally, the models are painted with bright primary colours which naturally attract the attention of children.

4. Uniquely Designed Mobile Labs

Figure.11 Agastya Mobile Lab. with rural children

The Agastya mobile laboratory programme was launched in 2002. A two man team of an instructor and the van driver operates the mobile van fitted with "Hands –On' Science Models which are in fact smaller versions of the Discovery Centre models that explain the basic scientific principles in the areas of Physics, Chemistry, Mathematics and Biology. The van is taken to remote rural schools with prior arrangement. On reaching the school, the instructor engages the school children for a period of two to three hours interacting with them with the help of these science models. The Agastya instructors teach scientific concepts through simple experiments in sessions that emphasize interaction and questioning. While most experiments are simple in nature and use material that is commonly available, the laboratory also has working models of the entire solar system.

Children are able to relate better to concepts explained through interactive demonstrations rather than through rote learning. They learn about a range of topics including astral bodies, rotation and revolution, the effect of gravitation, eclipses and how the brain deciphers signals.

Night mobile lab visits aimed at village community members, demonstrate the fun of science and encourage parents through such exposure to value learning and send their children to school.

Agastya Foundation runs a fleet of these mobile labs through out the rural areas of Andhra Pradesh and Karnataka.

5. Science Fairs & young Instructor Programs

Figure.12 Agastya Science Fair with our Former President of India

Science fairs are held to enable Agastya to reach out to large groups of children simultaneously. Using simple models, 12 to 16 year old young instructors demonstrate phenomena such as the solar and lunar eclipse, seasonal changes, concepts such as pressure and volume relationship and the protein chains that link together to form insulin.

Apart from teaching and demonstrating through experiments, the Science Fair also identifies and trains students to be young instructors. These students are provided training on science models in addition to building their capacities to present and interact with their peers. They then explain scientific concepts to other children at specially organized science fairs. It is found that the audience (children) is able to absorb information better as they can interact with their peer instructors without the fear of being reproached, eliminating barriers that normally exist between an adult and a child. Two Agastya young girl instructors from rural area won a Special Award at IRIS 2008, an annual science competition sponsored jointly by Intel, the Department of Science and Technology of the Government of India and the Confederation of Indian Industry. The girls were among 24 awardees from 1000 entrants across India and were the only rural children to win the award.

5. Conclusion

India, which has emerged as a major global IT power, is a country that regards science as a powerful instrument of growth and development. According to a recent study quoted by the ministry of science and technology, among the 149 top-performing countries in all fields, India ranked 13 for citations and 21 for research papers. As scientific temperament is carefully nurtured in the country, groups like Agastya play a vital role in helping the government in the task.

The Indian reality is a rural landscape where infrastructure facilities are minimal and finances scarce, where primary and secondary students remain dependent on prescribed texts to learn physics concepts like refraction and optics or phenomena like plant germination and photosynthesis. This linear and dreary approach not only kills enthusiasm but also deprives an entire generation of essential knowledge and understanding of concepts largely related to everyday living.

It is this shortcoming that Agastya seeks to overcome. With its aforementioned three pronged strategy of the Discovery Centre, uniquely designed Mobile Labs, Science Fairs and Young Instructor Programmes, Agastya hopes to impart lasting scientific knowledge and inspire curiosity to learn more amongst the rural children of our country.

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