The Buckyball Workshops for Small Children Prove that Science is the World Game

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INTRODUCTION

The discovery of the Fullerenes and the ubiquity of the basic geometrical patterns that govern their structure in the Physical World from tiny molecules to Meccano models and geodesic domes shown in Fig 1 a-c as well as in the Natural World from viruses and flies' eyes to turtle shells Fig 2 a-c was a key incentive behind the creation of a series of children's science workshops. As these elegant and beautiful structures had fascinated artists such as Leonardo da Vinci, Piero della Francesca and Albrecht Durer as well as ancient Greeks such as Archimedes and furthermore had led them to base their fundamental ideas of the structure of matter on deeper understanding of symmetry principles, it seemed ideal to use our new findings to awaken the curiosity of new generations of young people. The "Buckyball" workshops for small children have become an outstanding international success.

Fig 1 a) Pentaphenyl-C60 molecular derivative, b) Meccano model, c) The Epcot Centre Geodesic dome in Florida.

Fig 2 a) Virus, b) Australian fly c) Turtle shell

Workshops have been held all over the world from the UK, USA, Australia, Chile, China, Japan, Germany, Mexico, Italy, Spain, Sweden, Malaysia to Ireland. They have also been broadcast on TV in Japan and streamed on the Internet in the UK, Australia, Japan and the USA.

Fig 3 a *A Buckyball Workshop in Yokohama, Japan*

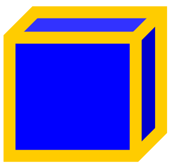
Fig 3 b *Avid interest during a Buckyball Workshop in Valencia, Spain*

Fig 3c A Buckyball Workshop with the help of the Manchester United Football team. Argentinian Diego Forlan and Irish John O'Shea both internationals helped me to teach the children algebra.

Fig 3d   Allessandro Del Piero showing children that science and football mix perfectly during a Buckyball workshop in Torino

Fig 3e Sessions often end with a complicated autographing session

We find that almost no small child has much difficulty in understanding how algebra works. We take a simple case such as that of a box:



They easily work out that when they count the number of faces on a box (6) add this number to the number of corners (8) and then take away the number of edges (12) they get the numeral 2. The same procedure for a pyramid also yields the numeral 2. Indeed this is true for any other closed polyhedral surface as the famous mathematician Leonard Euler proved a long time ago. We introduce them to this magic formula

Algebra

Faces + Corners – Edges = 2

The children can easily fill in a table such as this one

	F	C	E	= ?
	6	8	12	2
	4	4	6	2

The presentation has been translated into other languages such as Spanish, Italian, Japanese and Hindi

We talk to the children about how such shapes (Fig 4) appear in all different situations (Figs 1 and 2)

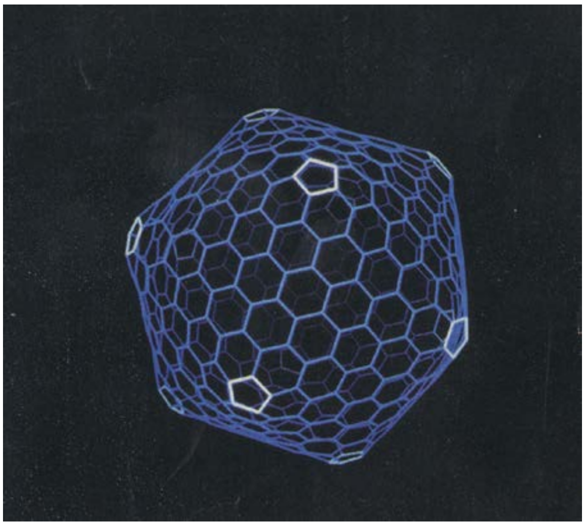


Fig 4   A Giant Fullerene

...and point out that there are 12 pentagons in the network (Fig4) and enable them to have hands-on, tactile experience of shapes and patterns (Fig 5)

Fig 5 Children during a workshop in Santa Barbara, California are fascinated by the beautiful shape of a Giant Buckyball.

I think it is important to emphasize that the ubiquitous image that many young people have that all scientists are old like the popular image that people always see of Einstein as an old man (Fig 6) is not correct.

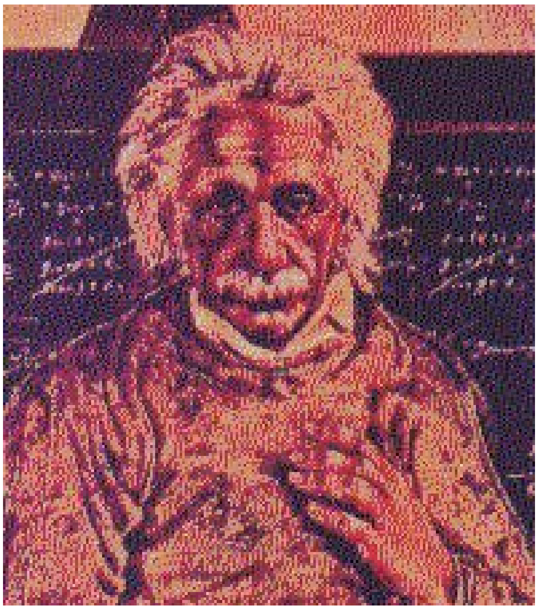


Fig 6 Painting of Einstein by Hans Erni

Fig 7   In fact Einstein was very young when he started to wonder what it would be like to travel at the velocity of light.

I tell them that in fact he was about 17 (Fig 7) when he first started thinking about problems that led to the brilliant and famous Theory of Relativity. I point out that young scientists such as Jim Heath, Sean O'Brien (Fig 8), Yuan Liu (Fig 9) and Jon Hare (Fig 10) worked with me any my colleagues on the research programme that led eventually to the Nobel Prize

Fig 8 Jim Heath and Sean O'Brien at Rice U Texas

Fig 9 Yuan Liu at Rice U Texas

Fig 10   Jon Hare at Sussex University UK

I emphasize the relationships between the Arts and the Sciences by showing the drawings of Leonardo da Vinci Fig 11 and that beautiful images are to be found in modern computer graphics representations of molecular structure at nanoscale dimensions Fig 12

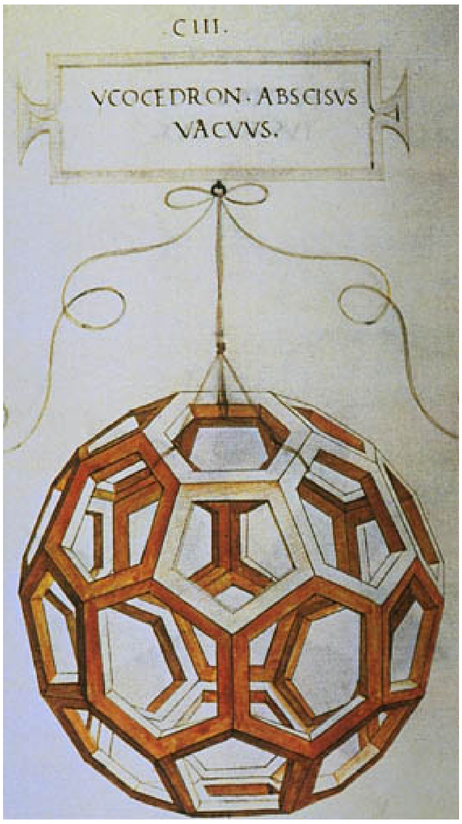


Fig 11 Drawing by Leonardo of a truncated icosahedron

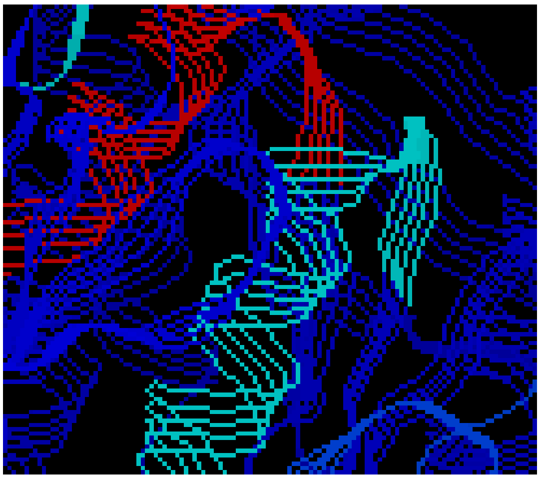


Fig 12 Part of a computer generated structure representation of a virus

A major and important part of the workshops is to encourage the children to build models such as the sculpture in Fig 13 which helps to bridge the divide between the Arts and the Sciences.

Fig 13   Buckyball sculpture built by children at a school in Sussex

Conclusions

The main part of the workshop programme is the hands-on building experience that the children get (Fig 14) from creating their own Buckyball model and observing the way in which it closes up – as if by magic - as they assemble the molecular model (Fig15).

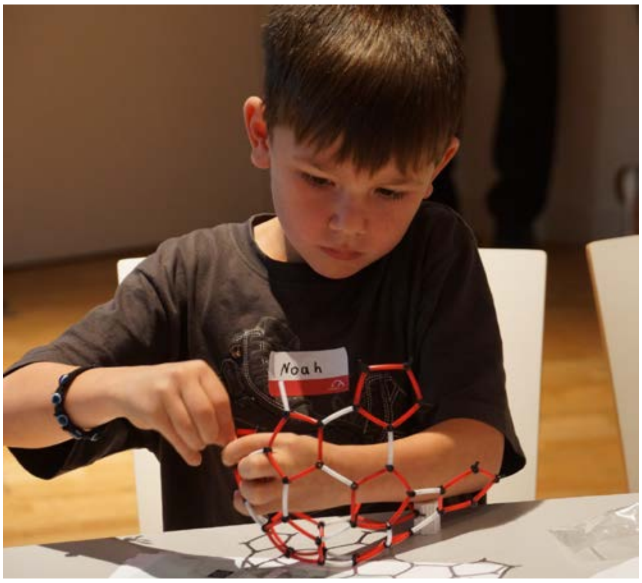


Fig 14   Every child becomes totally involved in the hands-on bottom up construction process as beautifully exemplified in this image of Noah in Hannover, Germany

Wherever we go in the world it is clear that science can catalyse tremendous enthusiasm and enjoyment of the creative process often resulting in imaginatively creative improvisation (Fig 15)

Fig 15 Almost invariably the children take delight in creative improvisation with the models such as this small boy in Shanghai balancing the Buckyball he has made on his head

The sessions invariably end with a communal photograph like this one (Fig 16) in Shanghai as the children gather around Margaret and me.

Fig 16 Communal photography sessions at the end of the workshops s are de rigeur

ACKNOWLEDGEMENTS
I wish to acknowledge the help of Jon Hare in developing the Buckyball Workshops and Margaret Kroto for most of the photographs at the workshops