Primary Schools as Engineering Centres

Abstract

The article describes the development of Mumbles Science 2000, and in particular: using primary schools as engineering centres; making use of the local science and engineering heritage; developing a universal base of equipment; providing stand-alone computer control; and integrating children with special needs.

Mumbles Science 2000 makes imaginative use of primary schools to provide engineering challenges all year round to children aged 5 to 11.

In term-time, our Roadshow takes science and engineering challenges into primary schools across South West Wales. In all school holidays, we operate in a primary school in Mumbles near Swansea:

- Science 2000 Club for 64 children each day, providing science and engineering challenges

- family events, at which children carry out engineering challenges with their parents or grandparents.

We follow the popular trend of using the word 'science' to encompass 'science, engineering and technology'. Those of us who are engineers regret this trend, but from a marketing point of view the positive, exciting image to children of the word 'science' helps to attract children (and teachers) to make use of our activities. Our objective as an educational charity is to help children enjoy learning about science and technology, with an emphasis on the word 'enjoy'.

On the road in term-time

We launched our Roadshow in June 1996, and now carry out about 80 day-long visits to primary schools each year. Roadshow visits are usually carried out by Julie Samuel, a mathematical engineer, or Ian Hill, a primary advisory teacher in science and design and technology. Before our launch, we carried out some fairly detailed surveys of primary schools in the area. Our objective was to find out which areas of the curriculum teachers would most welcome help with at Key Stages 1 and 2. The most popular by far was **Forces** in the science curriculum, followed equally by **Electricity, Sound, Light and Materials** in the science curriculum; **Structures** in the design and technology curriculum; and **Computer Control** in the IT curriculum. The survey also showed that schools welcome a Roadshow which can carry out projects with pupils in their own classroom, rather than a Centre which they have to visit. Visits to

Centres such as Techniquest in Cardiff can be very rewarding, but if you have to travel any distance to get there, the total cost and time lost in the school day is quite large.

Finding a Primary school with a local heritage

Once the Roadshow was established, we then started to look for a permanent base for our holiday science and engineering activities. We already had experience of running successful playschemes in primary schools, and carrying out one-day family engineering challenges. It seemed to us that a primary school would be an ideal base to set up a Science and Engineering Centre, which could open its doors every day in the school holidays. However, with some 200 primary schools to choose from, we also needed some additional selection criteria. We then started to look at the science and engineering heritage within walking distance of each school, with the aim of building the local heritage into some of the projects we carried out at the Centre. The search finally ended with our current primary school base in the seaside village of Mumbles, which has within walking distance of the school:

- a lighthouse

- a pier

- sandy beaches with rock pools

- a park

- limestone cliffs and quarries

- a 12th century castle in good repair

- the site of the world's first passenger railway [For the benefit of anyone reading this article in Stockton or Darlington, the railway operated its first passenger service in 1807, with a horse pulling carriages along a railway track.]

Andy Shercliff

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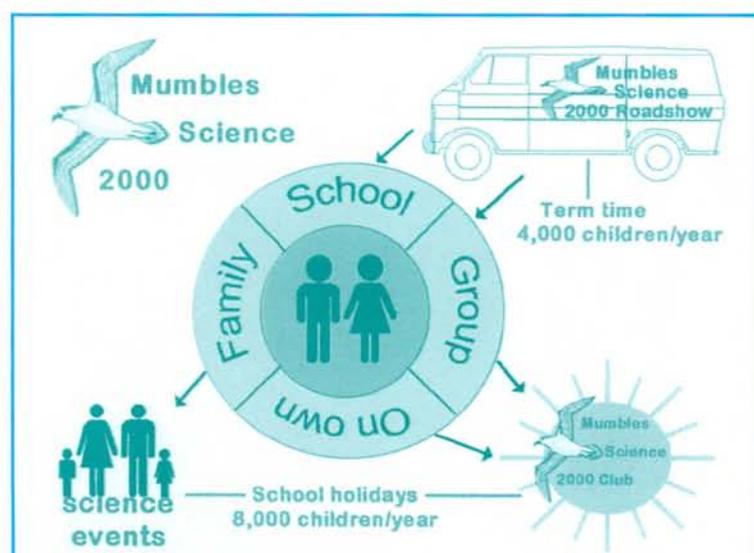Mumbles Science
2000*

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Figure 1

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Figure 2: The castle.

The beach and cliffs are excellent for science/geology projects, but mostly we use the local heritage in engineering challenges. Last year we ran a range of medieval challenges, in which children had to build their own castles, 'escape machines', siege weapons, and armour. This year we are following a 'Victorian engineering' theme, with railway, lighthouse and pier challenges.

Optimum use of primary schools in school holidays

Having selected our base, and negotiated a five year lease, we then set about deciding on a pattern of operation which would make optimum use of the school. After some experimentation with science playschemes and day-long family events, we have now chosen the pattern which seems to work best. This is:

Figure 3: A family engineering challenge.

• to combine childcare and out-of-school learning during the day time seven days a week (usually from 9.30am to 3.30pm), in a 'Science 2000 Club'

• to provide family engineering challenges in the late afternoon and early evening (from 4pm to 7pm) each day.

This pattern gives particular benefits to working parents and their children. Both types of activity are staffed by 'Helpers'. The name was carefully chosen, because their role is to 'help' the children to carry out challenges (not to teach them), and 'Helper' is a word that children understand. All Helpers are known by their first name, to avoid the formality of school. Our team of Helpers includes part-qualified primary teachers, recently-qualified primary teachers, and undergraduates in science and engineering. We do not pay very well (£3.40 to £3.70 an hour), but we find the Helpers enjoy the work, and for those who plan a career working with children, the experience is valuable.

A universal equipment base

Our science challenges on the Roadshow and in the Club mainly use traditional equipment bought from educational suppliers, although we like to think that we use some of the equipment in quite innovative ways. In terms of our Engineering challenges, though, we decided at an early stage to take a different approach.

In the early days, we experimented with a variety of materials and equipment, including Artstraws, scrap materials and equipment donated by industry. These often worked well for individual projects, but in a day we can be carrying out anything from three projects (on the Roadshow) to 50 projects (in Family events). Had we continued on this course, we would have needed a large van for the Roadshow, and a huge storage room for our Family Events and Club!

In Summer 1996, then we decided to adopt a more structured approach, which was to identify a 'universal base' of equipment for our Engineering challenges. We researched a number of possibilities, and ended up deciding that a versatile construction kit provided the broadest opportunities. We did look very hard at Lego, but decided it had moved away from its original strengths as a universal construction kit, to becoming a system of assembling specific components into predetermined models. We wanted something as versatile as Meccano, but which would be attractive to both boys and girls, and which could be used by 5 year olds as well as older children.

We eventually chose the K'NEX construction kit, of which we now have more than 250,000 pieces. K'NEX is a fairly recent product, manufactured in the US, and introduced into the UK in only 1994. However, its popularity is such that in four years it has captured a 20% share of the construction kit market. As well as having inherent structural and mechanical engineering properties which are

ideal for Engineering challenges, K'NEX is now very well known amongst children, and we find they are always keen to 'play' with it, either in school or at out-of-school activities. It is also very popular with teachers and parents, once they overcome their nervousness of anything new.

Initially we used K'NEX on its own, as a base for projects in structures, forces and mechanics. However, the launch of the Roadshow enabled us to 'extend' K'NEX so that we could provide projects in different areas of the curriculum. We first added to K'NEX:

• electrical components, such as battery boxes, lights and wires, which enable us to carry out challenges involving simple electrical circuits, such as our Mumbles Lighthouse challenge

• light components such as mirrors, to carry out projects such as our Periscope challenge

• sound components, such as chime bars and rubber bands, used for example in our Guitar challenge

• cladding components, such as correx panels and a variety of sheet materials, to give children opportunities to select and work with different sheet materials (e.g. in our Castle project).

Such challenges allow K'NEX to be used to provide the structure (e.g. castle or periscope frame) and any mechanics (e.g. the drawbridge opening/closing mechanism), with the extra components and materials then being added. This seems to us to be reasonably close to a real-life engineering approach, where often for instance a building is erected from a steel framework, and then clad.

Stand-alone computer control
More recently we have extended K'NEX into Computer Control in the IT Curriculum. Initially we experimented with using K'NEX models linked to 'control boxes' such as those available from companies such as Deltronics and Economatics. This worked well, but with two major drawbacks - the models had to have an 'umbilical cord' which attached them to the control box (not good for vehicles), and the control box required a stand-alone computer (e.g. a PC) to program it. The latter constraint was we felt particularly restrictive. We believe in doing whole-class projects, with the children working in pairs. This is fine if your school has a computer room with 15 or so computers and control boxes, but that rules out 99% of primary schools. Also, even the best computer-resident control software requires a minimum level of knowledge from

Figure 4: A whole-class project.

the operator. If you do not have this knowledge - as a child or as a teacher - you cannot carry out the project.

We therefore decided to develop our own equipment, and after a six month development project came up with the Phonemobile. This in essence is a computer housed in a telephone, which is controlled (and can be programmed) via the normal telephone keypad. The telephone also contains two motors, which are used to drive K'NEX models, whether they are vehicles, or static models such as a robot arm. Digital input and output sockets are provided at the back of the telephone, to connect devices such as switches and lights. Different 'modes' of operation also allow features such as a 'music mode', which allows music to be programmed into models (e.g. for a theme park ride).

We have now been using the Phonemobiles for nearly a year, with great success. We are particularly pleased to find that 5 and 6 year olds can use them to carry out computer control projects which one would normally expect from older children.
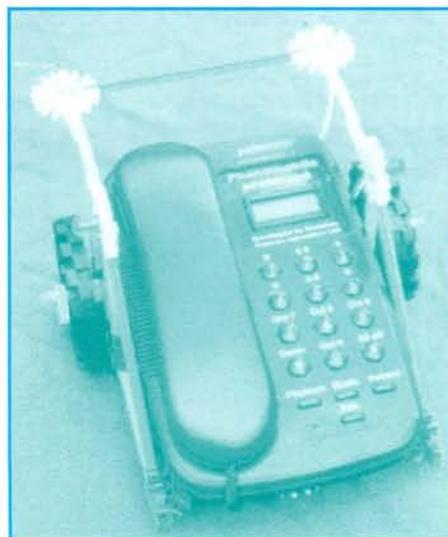

Figure 5: The Phonemobile.

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Figure 7: Our newsletter, Mumbles Seagull.

Mumbles Seagull

Helping children enjoy science and technology

Issue 10 January 1999

Welsh Young Inventors' Centre

The Mumbles Science 2000 team has grown considerably since we first launched our charitable operations 2½ years ago. We are now planning a major expansion and re-launch in the 1999/2000 school year, as the *Welsh Young Inventors' Centre*.

Our revised objective would be

→ *to help children gain confidence with Inventions and Discoveries*

We would still operate our successful programmes of science and technology challenges, but within a greatly expanded operation.

Please read on.......

Working with partners

We need partners to help turn our plans into reality....

In Wales:
- Children
- Parents
- Grandparents
- Primary Schools
- Children's groups
- Voluntary sector
- Public sector
- Higher Education
- Industry

Beyond Wales (eg UK and US):
- Educational suppliers
- Toy manufacturers
- Sponsors
- could you help us to make the Welsh Young Inventors' concept a success?

Some of the Mumbles Science 2000 team

Helping create an Enterprise and Innovation culture in Wales

After a wide consultation process, the *Wales Regional Technology Plan* concluded that the most vital development needed for the future economic prosperity of Wales was to develop an *Enterprise and Innovation culture*. We hope that the Welsh Young Inventors' Centre will develop a significant role in achieving this strategic objective.

We believe that children aged 5 to 11 need every opportunity to gain the confidence to make their own inventions and discoveries, which we can provide via our programme of science, technology, maths and IT challenges. Such experience is essential if the children in later life are to become Wales' future entrepreneurs, scientists and engineers, or if (as will inevitably happen) they need to make use of modern technology in whatever type of employment they enter.

Life skills
eg problem-solving,
a 'can-do' approach

Careers
eg entrepreneur,
engineer

Confidence with
Inventions and Discoveries
↑
Science, Technology, Maths
and IT Challenges
↑
Children aged 5 to 11

*Many thanks for the advice and encouragement already received, particularly from:
City & County of Swansea...Swansea University...WDA...Welsh Office...West Wales TEC*

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If you think the Welsh Young Inventors' Centre is a good idea **please return** the tear-off form on page 4. We need to show widespread support if we are to attract Lottery funding.

Even better, why not give us your ideas and suggestions at our *Children as Innovators* Conference on Friday Feb.19th - Booking Form on back page.

Many thanks to

Peter Hain
for agreeing to be the main speaker at our Conference, and to the

WDA for funding our Feasibility Study

Hope you like our new format for the Mumbles Seagull!

Please photocopy this Mumbles Seagull and pass copies on to friends and colleagues.

Young Inventors'
Clubs 2

Young Inventors'
Roadshows 3

Young Inventors
across Wales 4

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We are currently seeking a company who would be willing to manufacture the Phonemobile under licence, and then sell it to schools. Any revenue we earned from a licence agreement would help fund our charitable activities.

Integrating children with special needs

We are very fortunate that the old county of West Glamorgan (now the counties of Swansea and Neath/Port Talbot) had the highest proportion in the UK of children with special needs integrated into mainstream primary schools. This means that frequently when we take our Roadshow into a school, we are working with a class which includes children with a variety of special needs. It also means that when children with special needs attend our Club or Family Events, both they and their fellow children are used to working in small integrated groups with each other. This natural acceptance of integration makes our job much easier in meeting our objective to involve children with special needs in all our activities, on an equal basis. We also operate with a high adult:child ratio (1:8 or better), which helps us to ensure that all children in a group gains a high level of support.

We also take this objective into account in our project design. A major design criteria for our Roadshow and Club is that the explanation of each 'challenge' to the children is verbal. This means that children who cannot read, or who have difficulty reading, start on an equal footing to their peers. We often find poor readers turn out to be excellent at our challenges, and sometimes their capability surprises even their class teachers. It is to us a pity that the National Curriculum (and SATS) put such an emphasis on reading being an essential pre-requisite to science and design and technology.

With regard to children whose special needs are more profound than solely an inability to read, our successes are more variable. Some children with severe learning difficulties have carried out our challenges very successfully, and we find K'NEX can make excellent equipment for such children. This may be because once certain basic principles have been learned (e.g. how to joint rods and connectors), there is then no practical limit to the size or complexity of the model that can be constructed.

We have been less successful, though, with children whose physical difficulties make it difficult for them to manipulate the equipment or materials we provide. We have had some success by pairing such children with an able-bodied 'partner' of the same age, but it is not

Figure 6: Launching a water rocket.

always possible to ensure that the child with special needs operates on a genuinely equal basis in such pairings. We would welcome any suggestions on how we could improve in this area.

Summary

We have progressed a long way since we first launched the Roadshow in 1996. Much of our development has been by trial and error, in that we came up with an idea, 'test marketed' it with a group of children, and if it worked, developed it. We are also fortunate that we have been able to build up a first class team of staff, and that we have received funding from a wide range of organisations, such as local industry, West Wales TEC and the National Lottery Charities Board. We would be very pleased to hear from any organisation who has similar objectives and/or a similar approach, with whom we could perhaps exchange experiences and ideas.

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