

# **An Evaluation of the Formula Schools Engineering Scheme**

**Kick-starting Engineering Excellence in Schools**

# Kick-starting Engineering Excellence in Schools

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## **Evaluation commissioned and funded by:**

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**April 2001**

# Kick-starting Engineering Excellence in Schools

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## Executive Summary

The United Kingdom's engineering industry plays a key role in the economy. For example, engineering exports amount to 40% of all UK exports and in particular the UK's motor sport and specialist engineering industry is world class. The importance of this industry suggests that engineering should be perceived as an attractive and viable career path. However, engineering manufacturing has experienced significant changes, particularly in the structure and shape of the industry. The perception has been that the needs of the engineering sector are in decline resulting in a skills shortage in both technical and generic areas. However, the industry continues to make a significant contribution to the UK's economy and requires skilled people at all levels.

The engineering industry is particularly important in Oxfordshire with many motor sport and specialist motor industry companies sited in this region. Therefore, there is an excellent opportunity to raise the profile of the engineering sector, which will directly impact upon the needs of local employers and contribute to the engineering industry at a national/international level.

The factors associated with the people and skills shortages of the engineering industry are twofold. In addition to the problems with the industry, the structure of the national curriculum and issues within schools have resulted in few pupils learning engineering skills within the subject heading Design and Technology. Potentially, Design and Technology is one of the top four subjects taken by pupils but due to the structure of the subject and other educational pressures the engineering element is often not an option offered to, or taken by, pupils.

The Formula Schools scheme raises the profile of engineering within the school environment to engage young people in engineering related activities, providing curriculum delivery infrastructure. The scheme involves groups of pupils in designing, building and racing a petrol engine radio controlled car, learning and using a variety of engineering (and engineering related) generic skills. Schools engage with local businesses which offer funding or resources to help develop their car providing further excellent business experience for the pupils. The Race Day is the highlight of the scheme with all participating schools racing their cars in a true competitive environment. Trophies and many other prizes are awarded.

The evaluation exercise of the Formula Schools scheme has highlighted many strengths. This includes benefiting young people, the education and business sectors and ultimately the local and national economy. It is seen as a holistic scheme, which provides young people the opportunity to learn both engineering specialist skills and generic skills meeting the needs of engineering employers.

Overall there is significant support from all the main stakeholders to see the project continue and expand albeit in a controlled manner. There are specific issues with how engineering fits into the structure of the national curriculum, which can be addressed through working with educational bodies to communicate the needs of the engineering industry.

The success of the scheme provides a firm platform to begin expanding the scheme including opening up the opportunity for other regions to participate. However, it is important to manage a central core to ensure the ethos and quality of delivery is maintained.

# Kick-starting Engineering Excellence in Schools

## FOREWORD



Colin Whitfield

I am pleased to have been invited to write the foreword to this Formula Schools evaluation. This scheme provides pupils with the opportunity to show their skills in design and in engineering by providing real opportunities to work with professionals from industry. I was first introduced to this scheme when I visited schools in the Oxfordshire area and was impressed by the enthusiasm and determination with which pupils set about applying scientific and technical skills and knowledge in designing and building a radio controlled car. Then, to see the competitiveness and team spirit generated on Race Day convinced me that this was a very worthwhile educational experience and one that should be encouraged countrywide. Yes, it was fun and enjoyable but educationally very stimulating.

The curriculum area pioneering this work is Design and Technology, a subject that is now compulsory in our schools. This subject prepares pupils to participate in tomorrow's rapidly changing technologies. Pupils are encouraged to become autonomous and creative problem solvers, as individuals and members of a team. They combine practical skills with an understanding of aesthetics, social and environmental issues, functional design and industrial practices. Pupils learn to be logical thinkers - just the experiences required by industry and this scheme. Most of the applied science and engineering curriculum lies within Design and Technology and yet in many schools it is not given the importance it deserves. Some even think it should not be part of the National Curriculum. Old myths prevail: science is boring and for boffins, technology based subjects don't lead to real jobs and engineering is something that used to be done when Queen Victoria was on the Throne.

*"For some reason Britons look down their noses at people who make things. They push intelligent people into professions and into the media. Making things, however, should be an intelligent activity. Using your hands and your brains can be very productive and instinctive"*

James Dyson 1997

It is our responsibility to provide opportunities for young people, both boys and girls, to experience the joy of designing and making so that what they may do in later life is guided by first hand knowledge. Design and Technology has the ability to offer a rich experience in all aspects of learning and through Formula Schools pupils will be encouraged to develop creative multitalented minds ready to take their place in modern society.

This report shows the positive outcomes that are only part of the potential of this scheme, which itself is still in its early stages. The opportunity to work with like-minded professionals from industry, the business dimension and the hard edged engineering opportunities and creativity make this scheme unique. Making it work in schools is not an easy task. There are financial concerns, curriculum planning issues, health and safety, levels of understanding and staff commitment at a time when teachers are hard pressed. However, I believe this scheme is well worth the effort and support. Pupils get only one opportunity at school; let us ensure it is exciting and relevant. It falls to us all to invest in the future.



## COLIN WHITFIELD

Past President, National Association of Advisors & Inspectors in Design & Technology  
OFSTED inspector

# Kick-starting Engineering Excellence in Schools

## INTRODUCTION

The Formula Schools project seeks to significantly raise the awareness and importance of engineering within the education sector. This is to work towards responding to the skills shortage currently experienced by the nation's leading motor sport and engineering industry. The project encourages groups of pupils to work with a technological based company to design, build and race a radio-controlled car. The highlight of the project is Race Day when all teams race their cars at Silverstone and are judged in a number of individual competition rounds addressing design, technical, and business aspects of the project. The project is centred on the pupil and involves many different types of organisations/industry sectors working together. The project brings together all aspects of the learning in an exciting and innovative manner as well as addressing a core educational need. Ultimately it offers pupils an insight into the career opportunities in the engineering field.



The project began in Oxfordshire, in 1997 and has grown to have thirty-five schools entering in 2002 including schools from other regions. To this end, an evaluation exercise was commissioned by a number of key stakeholders in the project, in particular, the South East England Development Agency (SEEDA) and the Milton Keynes, Oxfordshire, Buckinghamshire Learning Skills Council (LSC). The purpose of the exercise is to evaluate the project to date and look at opportunities for expanding this and associated activities in the future.

The evaluation exercise has focused on the holistic nature of the project covering aspects of general participating and the pupils experiences as well as specific outcomes associated with pupils moving into the engineering field. A mixed number of evaluation techniques have been used such as, questionnaires, interviews, observations, general research. The techniques



used maximise on direct input from participants avoiding potential biases. An important factor of the evaluation has been to include feedback from many of its stakeholders. It is planned to develop the evaluation exercise as the project expands.

*The DfEE report 'An Assessment of Skill Needs in Engineering' gives a detailed and thorough assessment of current and projected skills needs in engineering, which will be a valuable source of information for education and industry planners.*

*It is available free of charge from DFEE ref no SD2*

*Tel 0845 60 222 60*

*Fax 0845 60 333 60*

# Kick-starting Engineering Excellence in Schools - Part 1

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## What is Formula Schools?

Formula Schools is a context within which pupils at secondary schools can experience and learn about engineering. The importance of this context cannot be over estimated, it has to provide a pull which can overcome pre-conditioning of what engineering is, such that pupils give it an unbiased hearing. It will remain as a snapshot in time for some, for others it will be the catalyst that turns them into the engineering thinkers and doers of tomorrow.

The initial objectives set for this project were:

- To promote engineering in schools and influence the young when considering their futures.
- To increase the number of schools offering an engineering curriculum
- To provide a sustainable and well resourced engineering curriculum model that schools will adopt.

## History

The findings of a report commissioned in 1996 by the Heart of England Training & Enterprise Council concluded that there were skills shortages at all levels of Motorsport Engineering. It was suggested that key initiatives could help change this profile. Formula Schools was one of three initiatives designed by the Oxfordshire Motorsports Taskforce. Banbury School ran a pilot to see if the scheme was a feasible way of encouraging young minds to take part in a sustained engineering challenge. Supported proactively from the outset by the leading edge Motorsports & Technology industry it has grown to include some 300 plus sponsor companies and 500 pupils per annum.

## Project Management

The management structure has mainly comprised of three parties, Steering Group, Co-ordination team and Funding Agencies. As the project has grown, a more formal structure is being implemented. This reflects the increasing work and diversity of the project, particularly the need for curriculum delivery.

## What do pupils do?

School teams link with a technology based company to design, and engineer, then race a radio controlled car powered by a petrol engine. Schools engineer their final solutions to score points in the following categories:

**Power-train and Chassis  
Body and Aerodynamics**

**Teamwork and Marketing  
Driving**

This innovative scheme introduces pupils at an impressionable age to the world of engineering. It dispels the myths surrounding engineering and lets young people experience at first hand, many aspects of team-working in this environment.

Using the 'shop window' of Motorsports Engineering as a context, participants work to a critical and very public competition deadline.

The scheme provides materials and specialist support for curriculum delivery, including: GNVQ Engineering, GCSEs in Systems Control, Electronics, Resistant Material, Product Design.

Activities supported by the scheme include:

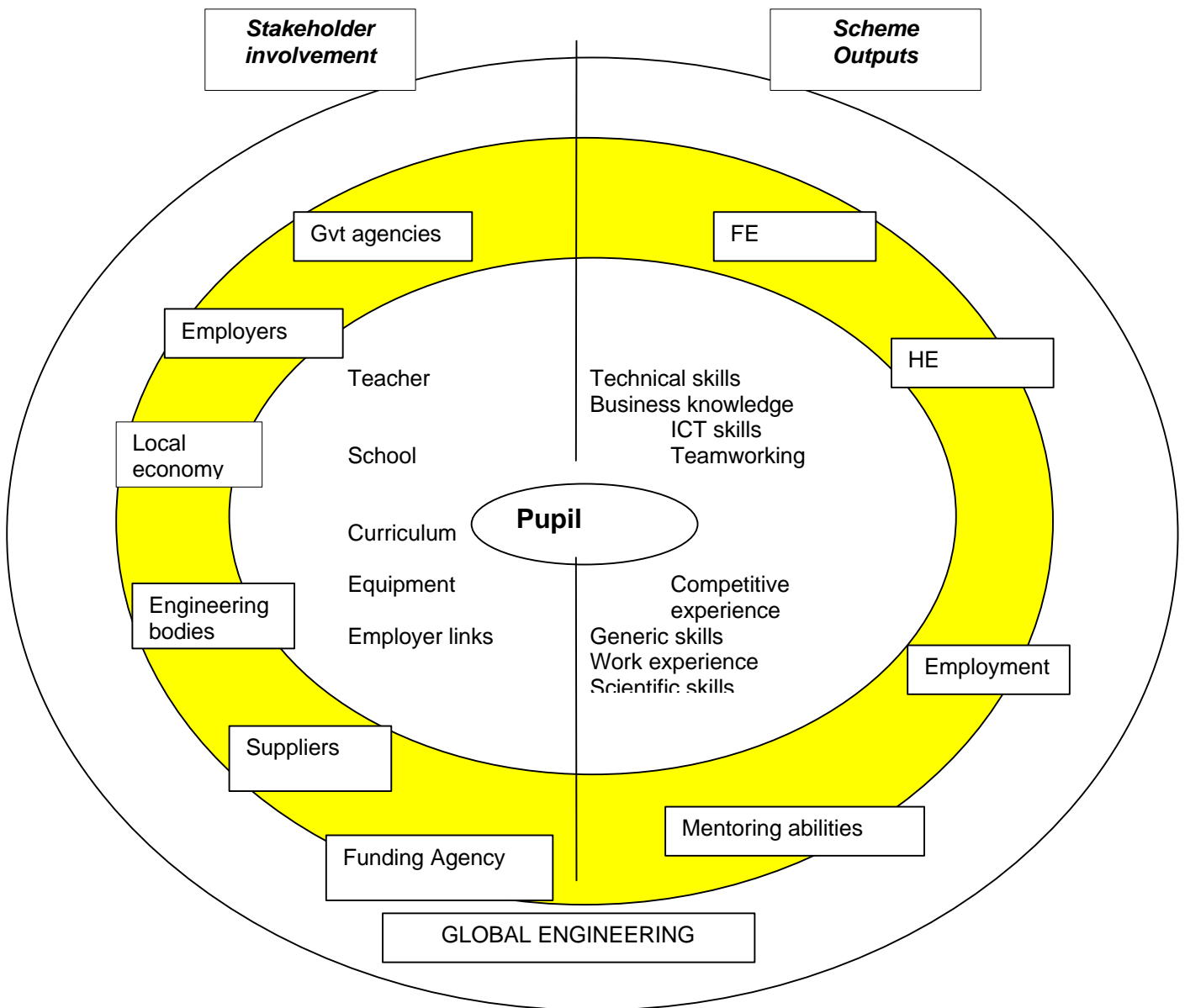
- ⊙ Electro-mechanical engineering skills
- ⊙ Telemetry systems using Opto-Electronics
- ⊙ Timing devices using LASERS
- ⊙ Data capture from school engineered Dynamometers
- ⊙ Communication and marketing systems such as team Web Sites, presentations etc.

All this adds up to young people experiencing the application of scientific / technical skills and knowledge often not available in mainstream education.



# Kick-starting Engineering Excellence in Schools - Part 1

## Scheme in terms of Inputs and Outputs



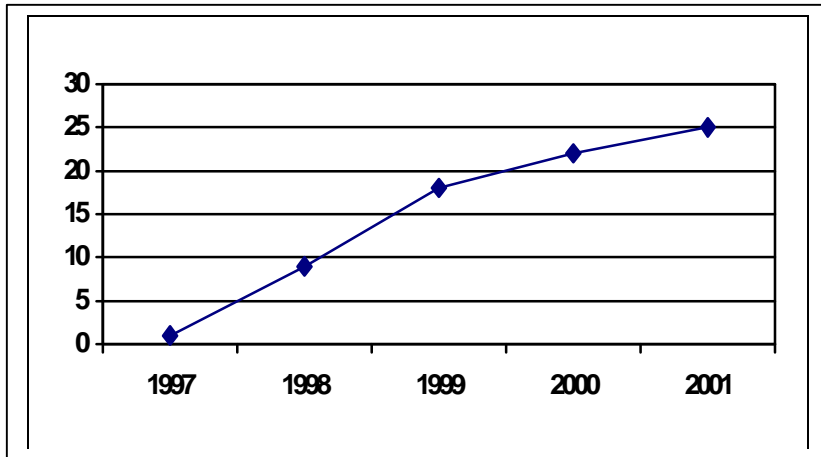
This shows the project as being pupil centred and supported by many stakeholders with different levels of involvement. It demonstrates how the project has a ripple effect impacting locally and beyond.

One of the most valuable outcomes is the way in which companies work with their partner school(s). Most provide engineers to support the scheme both in schools and at company locations. Staff who have worked with schools over the last four years have themselves found it a rewarding experience. Sharing their skills, knowledge and enthusiasm with the young; stimulating them to follow in their footsteps. Often describing it as 'an investment feeling, putting something back'. For most, it is the first time that they have been back to a school since leaving themselves.

Mentoring by pupils who are 'old hands' provides further human resource to technology faculties in knowledge transfer to younger year groups. Where this has been done on a formal basis the value added evidence of engineered output and motivation are considerable.

# Kick-starting Engineering Excellence in Schools - Part 1

## Number of schools taking part in Formula Schools



Formula Schools was first run in 1997 as a pilot in Banbury School with 84 pupils in 10 teams.

The total number of schools, that have taken part during the life of the scheme is 35; representing some 1500 plus, pupils.

## Financial Information

The scheme is funded annually by local government agencies and sponsor companies. The costs equate to approximately £ 2,500 per school. The funding structure provides an opportunity for schools to significantly enhance their applied science and engineering resource. For example, it is not untypical for schools to raise in excess of £1,000 cash or more and for companies donate equipment.



Lord Williams's School Thame receive a cheque from E<sup>2</sup> Engineering

The main sources of income and expenditure are as follows:

<b>INCOME</b>	<b>EXPENDITURE</b>
<b>Cash and sponsorship</b>	
Funding Agencies	Materials and equipment
Company contributions - cash - time - equipment	Race Day
School contributions - cash - time - resources	Management -personnel -marketing -health and safety -insurance -resources -associated activities
Consultants time	Consultants

# Kick-starting Engineering Excellence in Schools - Part 2

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## Why have Formula Schools?

## Why is engineering important to the nation's economy?

".....the biggest single factor holding any company back was a lack of skilled staff."

*Dave Williamson  
reflecting on the reasoning behind the formation of Formula Schools*

This section explores the impact the engineering industry has on the local/regional and national economy. These factors support and assist the overall direction of the Formula Schools scheme. This is particularly important as five years on from the pilot scheme the impact of Formula Schools and its future must be considered.

### Key Facts

- ⊙ The United Kingdom's motor sport and specialist engineering industry is world class.
- ⊙ However, few young people choose engineering as a career path at secondary school.
- ⊙ Perspectives given by parents and, very often, career guidance are not up to date, painting a poor image based on myths and mis-information.
- ⊙ The long term solution to this problem lies in stimulating talented young minds to choose technological education and career pathways

### Nationally

- ⊙ *Engineering exports amount to 40% of all UK exports*
- ⊙ R&D spending in engineering (£3bn) is one third of all industries
- ⊙ Capital expenditure in engineering (£8bn) is almost half of total manufacturing investment
- ⊙ Engineering sales were £175bn in 1997
- ⊙ Engineering output contributes 8.5% and manufacturing nearly 20% of GDP
- ⊙ *Engineering employs 1.8 million highly-skilled employees, 45% of total manufacturing employment*
- ⊙ Only 15% of engineering employees are aged 16-24 (EMTA)
- ⊙ 20% of employees are women (EMTA)
- ⊙ *49% of engineering employers had hard-to-fill vacancies in 1998, with the Motor Vehicles sector reporting 58% (EMTA)*

Source: EEF (unless otherwise stated)

In addition, a report from the Department for Education and Employment (DfEE), *An Assessment of Skill Needs in Engineering*, (Autumn 2000) further confirms the importance of the engineering industry to the national economy. Key points from the report are as follows:

'Skill Shortages are apparent at all levels but especially at the higher end of the occupational spectrum, among professional engineers and also in skilled (craft) trades, including electronics and IT skills. The main skills gaps are in specific technical and practical skills areas but personal and generic skills are also in short supply.'

'It is estimated that around 2.5 million people are in occupations that have some engineering component, about half of whom (1.3million) are in substantially engineering occupations. The majority of those are found in engineering manufacturing, though a number of other sectors have substantial numbers.'

structure of the industry has changed in many ways which have implications for skills. There has been a shift in the occupational balance towards the more highly-skilled and educated. Jobs have become more demanding at all levels, and there is an increased use of cell and team working.'

'...there will continue to be a strong demand for training and job opportunities in engineering, as estimates of 'replacement demand' outweigh the negative expansion demand forecasts at all occupational levels. Some of the largest numerical net requirements to 2009 in occupations of relevance to engineering are forecast to be in the corporate manager, science, and technical professional and skilled metal and electrical trade groups.'

# Kick-starting Engineering Excellence in Schools - Part 2

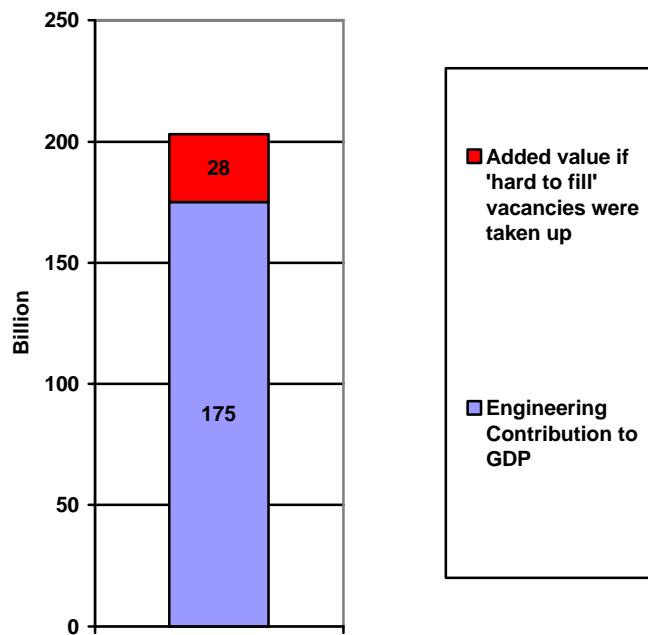
'A number of drivers of change are acting in unison to change skill requirements in a range of jobs. These include the increased use of technology, new materials and new processes throughout industry, an increasing emphasis on customers and meeting their requirements, new working practices and the globalisation of many aspects of business. These demand higher-level skills and education and also greater breadth of skill and greater flexibility in the application of skills.'

### What is the cost of the Skills Shortage?

A scenario of direct proportionality between sales and the preferred staff profile for the industry gives a figure for increased sales of £28 billion.

Whilst this 'finger in the air' approach to sales potential is subjective the lack of skilled staff at all levels will have an incalculable cost to U.K engineering.

Adjustment to the national engineering sales figures can be seen in the following chart.



Engineering sales

Taking engineering sales as being £175 billion and recognising the 16% of vacancies in the engineering industry are described as being, 'hard to fill'.

The most critical areas being, Design Engineers, Electrical Engineers and Electronic Engineers.

### Regionally

- ⊙ Manufacturing industries were forecast to contribute more than £17bn to the South East economy in 2000
- ⊙ 15.8% of the UK's Engineering Companies are in the South East (highest of any region)
- ⊙ The sector employs 500,000 people

These factors demonstrate the enormity of the engineering industry in a national context. However, public perception would not necessarily reflect this and therefore raising the awareness of engineering and what it now means and can offer as a career opportunity needs to be embraced. This opportunity is most appropriately carried out during school years, with the added factor of an entrenched gender bias not having a substantial foot hold.

# Kick-starting Engineering Excellence in Schools - Part 2

## The Position of Engineering related studies in Schools

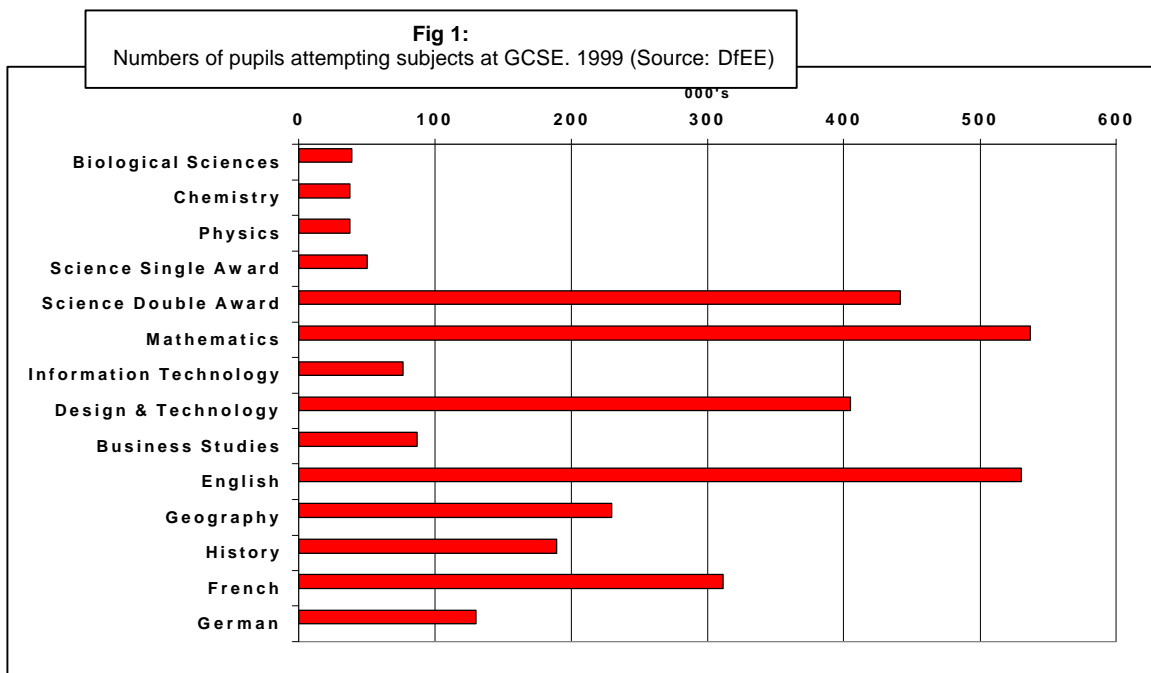
“.....engineering wasn’t being seriously considered by children at the ‘options’ time of their

Dave Williamson  
reflecting on the reasoning behind the formation of Formula Schools

Given the importance and the needs of the engineering industry, as identified in the previous section there are some excellent career opportunities. It would therefore be a missed opportunity for young people not to encounter this as part of their education.

*Do pupils have the opportunity to study engineering in school?*

Engineering is currently delivered through the Design Technology subject area. Nationally all pupils have entitlement to this Technology curriculum. It is a legal requirement that all state sector pupils in England and Wales study Design and Technology until they are 16 years old. The chart below demonstrates the high numbers of pupils who study this subject area, almost equating to that of Maths, English and Science.



**However,**

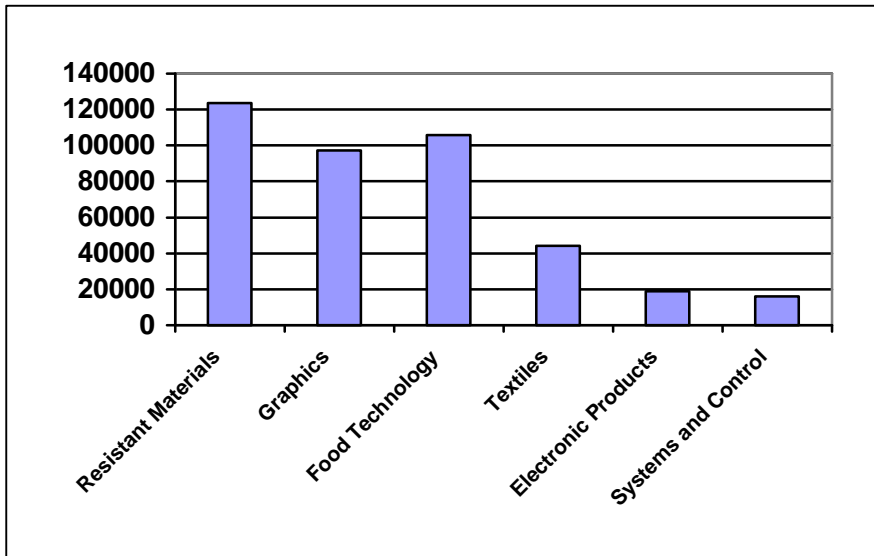
Exposure to applied Science, Technology and Engineering in our secondary schools is a very mixed bag. The prime delivery vehicle (Technology) has many alternatives of differing stature and content, all labelled Technology.

Within Technology there are sub sections in terms of sector specific study including many aspects of the applied science curriculum.

- ⊙ Resistant materials
- ⊙ Graphic products
- ⊙ Food
- ⊙ Textiles
- ⊙ Electronic products
- ⊙ Systems and Control
- ⊙ Product Design (available from 2003)

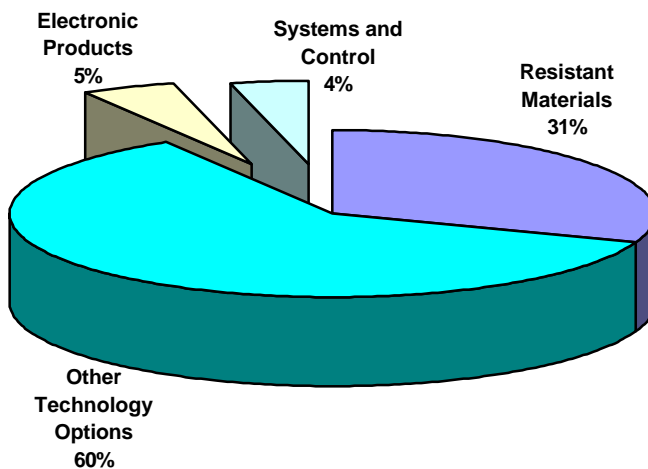
# Kick-starting Engineering Excellence in Schools - Part 2

A key issue is that only three of the Technology subjects include specific engineering based skills and knowledge. These are Electronic products, Systems and Control and Resistant Materials. The chart below (Fig. 2) demonstrates how few students take two of these subjects. The third and most popular option, Resistant Materials covers such a broad spectrum that it can be very variable in its content, particularly in relation to processes. Some pupils will engage in advanced design and manufacturing, whilst others will follow a more creative approach, learning little about materials and manufacturing in a 'real world' context. Conversely, Electronics and Systems Control have a tightly prescribed curriculum in terms of materials, components and processes.



**Fig 2:** Breakdown of Technology options and pupil numbers. 1999 (Source: AQA)

The following chart (fig.3) demonstrates the small numbers of pupils who actually engage in engineering related studies through electronic products and systems control. There is potential within 'Resistant Materials' for substantial numbers of pupils to experience a quality materials and related processes course. Many pupils miss this opportunity as the actual delivery route taken is one of expediency in achieving grades by producing 'artistic' products that teach little about material properties but 'look good.' The other Technology Options do not cover engineering and include the subjects, Graphics, Food and Textiles.



**Fig. 3**  
Design and Technology GCSE 2000  
Source AQA

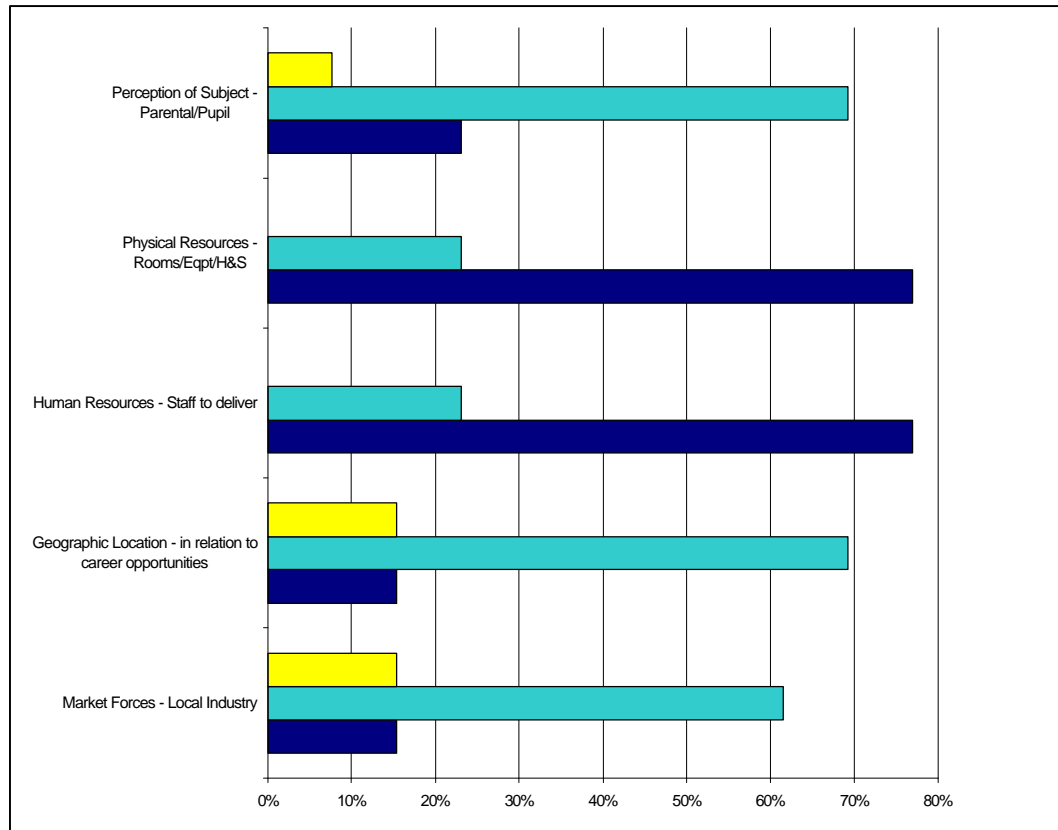
# Kick-starting Engineering Excellence in Schools - Part 2

## Why is there such an Imbalance in the Technology experience for pupils in different schools?

Feedback from thirty schools where their curriculum managers were asked what were the key factors when deciding the sectors of Technology they offer.

### Issues affecting the decision to deliver Applied Science Technology and GNVQ

(Sample 32 schools)



Ranking of issues in terms of importance regarding the Technology curriculum offer	
LOW	Not an important factor
MED	Forms part of the decision making process
HIGH	Critical to making a decision

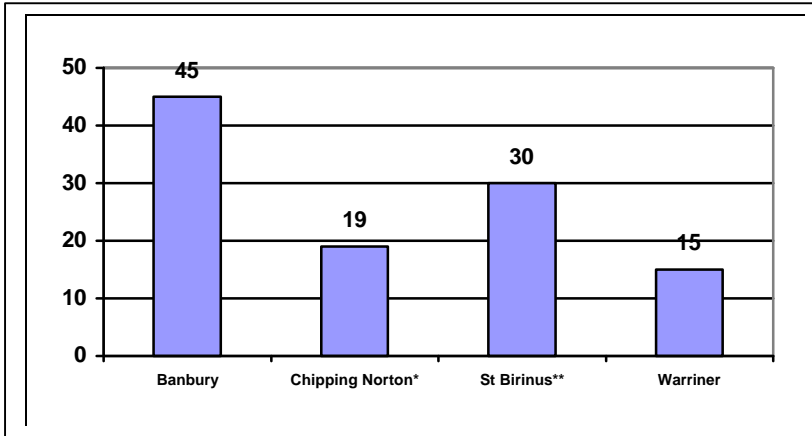
### Further points

- ⊙ The single largest reason for a reluctance to offer the 'hard' technologies is the lack, or perceived lack, of staff and hardware
- ⊙ The perception that regional needs, in terms of skills and knowledge, can influence a school's curriculum offer is not a widely held one.
- ⊙ Feedback suggests that schools feel removed from the sway of 'short-term' needs and deliver a 'balanced' curriculum at this age and stage of education.
- ⊙ The 'norm' has become a curriculum which is most effective in meeting the needs of a league table led rationale.
- ⊙ Vocational links which require 'servicing' are largely the preserve of Further Education.
- ⊙ League table yardstick driving curriculum selection from Technology options, i.e. the subject sectors most likely to deliver higher grades are the most popular choice with many curriculum managers.

# Kick-starting Engineering Excellence in Schools - Part 3

## The Impact of Formula Schools

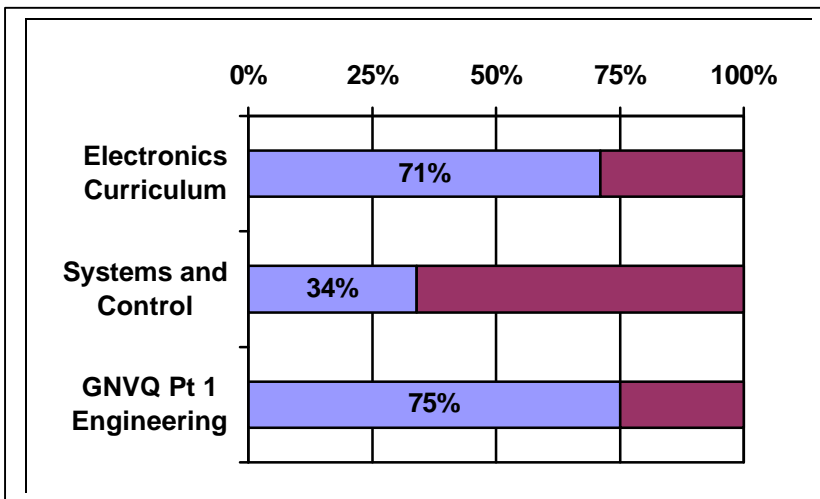
The school subject most suitable for embedding Formula Schools is GNVQ part 1 Engineering. This will be replaced with Vocational GCSEs in the next year or so but the skills and knowledge base will remain much the same.



Combination of Oxfordshire Schools Delivering Formula Schools and GNVQ Engineering in 2001, Including number of pupils in the groups

\* = Formula Schools through GNVQ Manufacturing

\*\* = Year out due to staff change

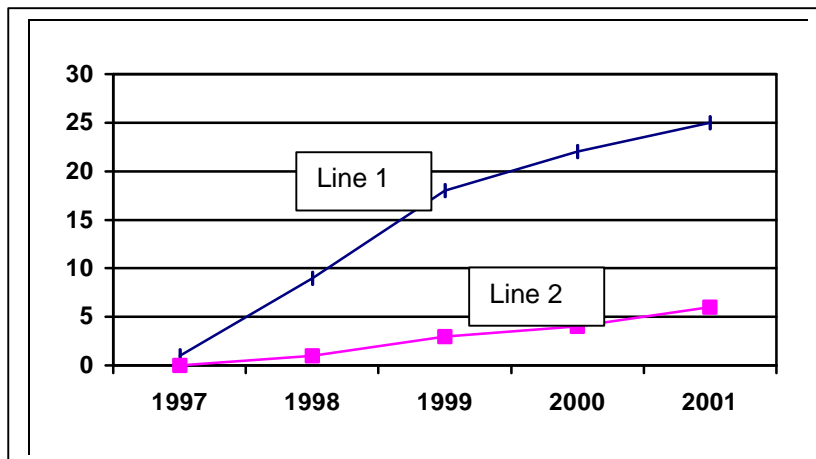


Proportion of Oxfordshire's Engineering Curriculum in Formula Schools centres 2001

Formula Schools centres



Non-Formula Schools Centres



Line 1  
Growth trend of Formula Schools

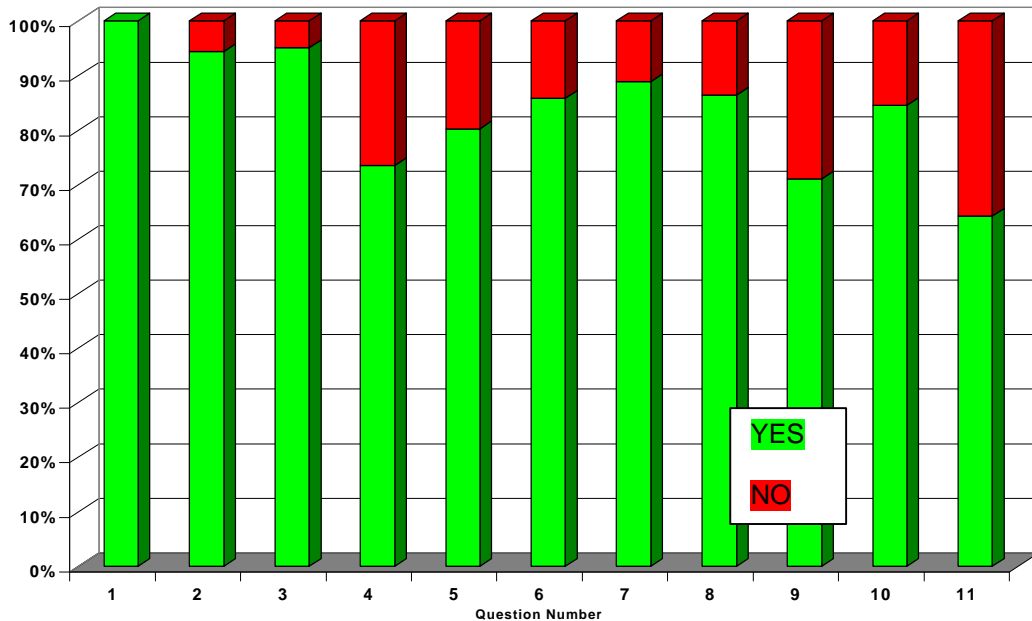
Line 2  
Growth trend of schools delivering Engineering

# Kick-starting Engineering Excellence in Schools - Part 3

## Schools Feedback

Pupil Survey Results. Questions 1-11 .

Sample 182 returned questionnaires



### Questions

1. Would you do the scheme again?
2. Did the image of motorsport encourage you to take part?
3. Do you now know what a motorsport company does?  
*Have you learnt new skills as a result of Formula Schools?*
4. Welding
5. Materials selection and use
6. Working with others, e.g. team members in schools, sponsor company
7. Organisation to get things done well and on time
8. Would you like to do the work for Formula Schools as part of a subject?  
e.g. Technology, Engineering, Business Studies
9. Have you met people working in engineering through the scheme?
10. Do you think there are career opportunities in engineering?
11. Are you interested in other aspects of engineering?

### Pupils

The work on opto-electronics gave me the starting point for my A level projects. I have produced a data-capture system for the dynamometer. This includes engine temperature, revs and power. The data is sent by multiplexing a Laser beam and can be picked up reliably at a considerable distance from the test hardware.

Daniel Rainbow, Magdalen College School, Brackley

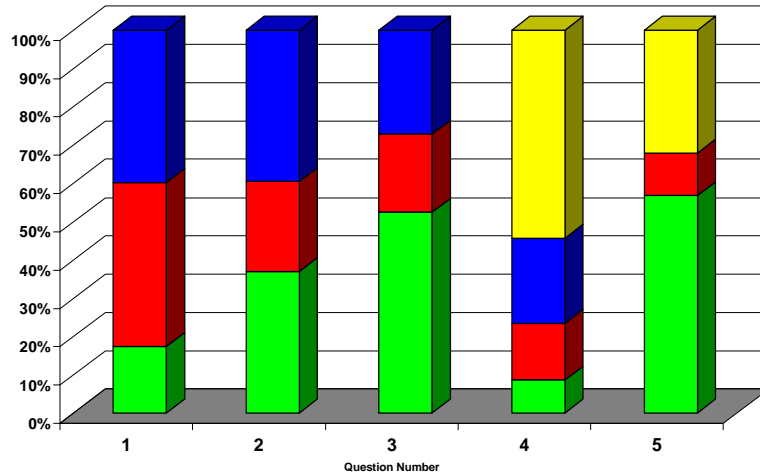
'Robert has set his heart on being an engineer since first school, and has never wavered! However, the competition challenges really worked to open his eyes to all sorts of aspects of what being an engineer involves- things like team work and processing ideas, and being realistic in putting them into practice. All in all, the whole thing works well just at the right level for the participants'

Parents of Participant



### Pupil Survey responses

# Kick-starting Engineering Excellence in Schools - Part 3



### Questions

- Have you used the web site?  
not at all sometimes frequently
- Was this to:  
help the challenge school subject work mixture or just for interest
- Do you combine any of the work with your subjects?  
Technology Science Other
- How much time do you spend on the challenge per week?  
1hr 2hrs 3hrs 4hrs+
- How was Formula Schools publicised to you?  
Engineering challenge model car club Other

It has taught us to work together, but each person is concentrating on different aspects of the challenge so that we meet the deadlines. No one on their own could have entered and won this competition. That is the real difference from this and the GCSE work we do at school.

Wheatley Park School

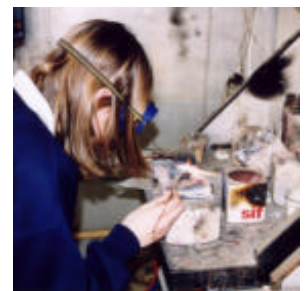


We would never have done any form of engineering if it had not been for this competition. We do not have the equipment to make different chassis but a professional aerodynamicist has come in every week to help us design and make a body shell. We have learnt a lot about body design and testing, including the use of composite materials.

Pupils at St Edmunds Girls School Salisbury

Most of our GNVQ work is based on the Formula Schools challenge, it makes it more interesting than just doing projects for the sake of it. We researched tyres and body construction for composites, Etorre Bugatti for a case study and different types of machining for all the mechanical components.

Pupils from Banbury School studying GNVQ Engineering



# Kick-starting Engineering Excellence in Schools - Part 3

## Case Studies

### Warriner School

#### GNVQ part 1 Engineering. 15 pupils starting Sept 2000

Warriner, like so many schools considering running an Engineering course, had problems to overcome, with staffing, equipment and marketing to potential pupils being at the top of the list. The conventional route is one of skills and knowledge acquisition through assignments covering focused areas. These are enhanced and put in context through project work; the choice of which, (combined with the quality of delivery) is the thing that will remain in the minds of the pupils the longest, and establish a reputation for the course.

The course developed by Warriner was launched in September 2000 with the Formula Schools element as a contributor. By working closely with the tutors to provide curriculum resources the Formula Schools contribution escalated to a point where a policy decision has been taken to have it at the core for of the course in this and future years. Formula Schools provides opportunities for all activities prescribed by the programmes of study and gives opportunity for individual projects to grow from them. The embedding of the Opto-electronics work has made complete content delivery possible and popular. Pupils have shown themselves to be far more motivated to learn the skills associated with electronics when using infra-red, fibre and LASER systems, although the core principles of opto-electronics cover all conventional ones as well.

'It is vital that this sort of scheme impacts upon two areas: The curriculum schools have to deliver and the relevance of the knowledge and skills base in the eyes of pupils. The move to embed electronics into this context has been the deciding factor in retaining Warriner's involvement. So long as the scheme has the ability and resources to assist in a very real way directly into the classroom we will continue to participate. This year the pupils have returned from Race Day focused on achieving the highest standards in their GNVQ assignments.

***Formula Schools has turned a corner that few 'schemes' ever realise the existence of, let alone achieve.'***



Graham Curtis, HOF Warriner School

The use of Formula Schools cannot be underestimated both in the class and the school as a whole. From marketing at open evenings to encouraging pupils to learn how to weld; Formula Schools works.

We could not have sustained the interest and hard work without the buzz of the big picture in terms of what we were trying to achieve as team.

Now we have taken part for the first year we will be back, starting earlier with the GNVQ classes and using it as a recruitment tool for lower years.

Keith Harper GNVQ Engineering course leader

With the addition of opto-electronics, the project reaches even more areas of engineering, and gives students the opportunity to develop complimentary skills. It has inspired the minds of individuals in our team to incorporate areas of this project into their GCSE's helping to raise standards at the end of KS4

***"In 23 years of teaching, I have never more enjoyed seeing so many students in one place absolutely engrossed in what they were doing, the best day out in my career!"***

Curriculum Manager Surrey



## Case Studies

### James Campbell

#### Trainee Electronics Engineer with Aston Martin Lagonda

James as a student was a good all-rounder, and other than a liking for making things had no hard and fast preferences in terms of career.

As part of the community service programme at the school James chose to involve himself in Formula Schools 2000. His involvement was conscientiously carried out week by week working with the students who were engaged in the body shell design and manufacture. This involved him in the design and use of moulds, composite materials, surface finishing and wind tunnel testing. This window on engineering brought him face-to-face with professional engineers who were working in the school on the project.

Like many students James wanted at least a year out whilst he decided what to do, as although a direct route into higher education was an option he also wanted to get into the world of work. When speaking with Arthur Sinclair of Aston Martin Lagonda James had been noticed as a student with potential. He was offered a place at Aston Martin, to work on electronic systems and soon forgot about his year off.

Two years on, Arthur Sinclair describes him as an outstanding success story who is now very involved with his subject area.

The role at AML has evolved into becoming a trainee Electronics Engineer with wide ranging projects and tasks. He says that flexibility and being a team person are essential qualities to succeeding in a field of advanced technology. He enjoys nearly all aspects of his job, not least the opportunity to travel and test some of the most exotic cars in the world.

Whilst working with AML James is studying at Coventry part time which will take him through to an Automotive Engineering Degree in Electronics.

James followed this path as a result of the opportunities that gave him an effective interface into motorsport engineering with contacts.

### Gemma Lawrence

'I got involved with Formula Schools when I was a pupil at King Alfred's School Wantage. I took the lead in producing a wing for the car and with a week to go before race day needed some expert help. I took it to Jordan F 1 where I had a work experience placement and worked with their composites section to construct one out of carbon fibre.

Since leaving King Alfred's I have gone on to the BEng (Hons) in Automotive Engineering at Oxford Brookes University. As part of the second year I will be taking part in the Formula Student Challenge as part of a team designing, building and racing a full size single seater; just like Formula Schools, only bigger, and hopefully faster!'

### Katie Nelson

Katie is a pupil at Banbury School where Formula Schools is used for curriculum delivery of GNVQ part 1 Engineering.

'This project has brought engineering to life, in particular the way in which we have used the work of Etorre Bugatti as a base for a lot of our work. This has included producing a 1/7<sup>th</sup> scale Type 59 car to enter for the Formula Schools race. As a group we engineered all the components from rear axles to welded aluminium bodywork and then assembled them to produce a race-winning car. I would like to follow on to Motorsports engineering in the future and hope to gain a work experience placement within a suitable company. I am sure that my involvement with this year's project will help me in the future as well as right now in covering the course content.'



# Kick-starting Engineering Excellence in Schools - Part 3

## Companies Feedback

**“...our direct involvement is optional, but our support is essential...”**

Dave Williamson. (former M.D Parallel Motion)

Engineering companies both familiar and unfamiliar with the scheme were asked for their views on the skills and knowledge profile for pupils which would be advantageous if deciding on; and being successful in, an engineering environment.

The following are the top four responses:

1. Teamworking
2. Enquiring mind
3. Practical ability in selected disciplines, e.g. mechanical engineering, electronics, Computer Aided Design, CNC machines,
4. Mathematical understanding

The feedback from middle and senior management highlighted the ability to work as part of a team as critical in nearly all technology-based companies. There are few instances where individuality can overcome poor team working skills.

Jez Coates of Caterham Cars best sums up company responses:

'Creating a mindset in the young that says "I want to experiment and improve" will develop skills that have become alien to generations. The person who designs and build his or her own components, tests them and then improves on them is far more interesting to us than one who possesses only theoretical knowledge.'



### Further comments typical of all companies

'All positions require confident 'teampayers' with a flexible and positive 'can do' attitude. In return for your commitment and hardwork you will be rewarded by a competitive package and excellent working environment.'

B.A.R

'We would rather take on a person who had not attempted a programme or qualification, rather than one who failed it due to a lack of application'

Transense Technology

Engineering is not a popular idea with young people as they see it, being dirty and hard work. In some cases this is still true but they do not find out about the full range of opportunity by taking this stance. Image is such an important factor, especially to the school leaver entering employment for the first time.

Colin Wood. Swan Foundry

### Comments from sponsor companies relating to direct involvement in the scheme

The UK is the centre for the global motorsport industry and it is important that schoolchildren understand more about what goes on in this sector. Some of those that take part in Formula Schools will undoubtedly go on to successful careers in motorsport, however for the vast majority, it makes for a new and exciting project which is very different from what they would experience in the standard curriculum.

Sue Brown. Human Resources Director. Prodrive

## Kick-starting Engineering Excellence in Schools - Part 3

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I believe the scheme has far exceeded the original expectations. It has proven to raise interest in engineering and in certain cases helped individuals to refocus on school work. More and more schools want to join and to use the scheme within the curriculum rather than an add-on. For me, this is the greatest measure of success.

From a Company point of view, we wanted to support a local initiative with Schools but this scheme has gone far beyond that now and has become an important initiative within the Company with links from our Web site and articles about the scheme distributed internally and on the web-site. **I am certain that in a few years we will receive applications from engineers which include taking part in this scheme on their CV and which will give them a distinct advantage.**

And amongst all of this, to see so many students on race day excited, enthusiastic, working as a team with ideas and energy is another measure of its success.

To get the job in the first place an individual needs to have a skill and to be able to apply it in a practical way. To be successful, they then need to be able to communicate well, work as part of a team, be innovative and proactive. We have experienced many situations where someone is an expert in a particular field but is an individual and cannot work within a team and so we cannot use the expertise.

Linda Willis. Human Resources Manager TWR Arrows

This involvement at school level has far exceeded my expectations. It has not only raised interest in both mechanical and electrical engineering, but also for each team of children we saw at Silverstone there was another team we didn't see who had sent out proposals to sponsors, designed web sites, sorted out graphics for the car and all the other jobs we all know exist behind the scenes of any successful business.

This to me rates as 110% success, we have motivated a number of children to see a purpose for their education, pursue a given career and put effort into achieving their goals.

These are all future employees of UK PLC and as such the country will be better off for us having lit a spark of interest now.

Dave Williamson (former M.D Parallel Motion)

The scheme gives pupils an opportunity to find out what it is like to be up against an immovable deadline. The learning that takes place prior to race day in developing skills that are not well covered is vital to the success of our industry. On race day these skills are put to the test in just as real a sense as the members of our race team in a round of full scale premier motorsport.

Race Team Manager. Prodrive

If the end product of supporting this form of education is the ability to recruit straight from schools offering engineering, it has our full support. Teaching pupils how to apply scientific and engineering skills in schools through linking them to commercial reality is important if perceptions are going to change about engineering disciplines.

Production Manager. Aston Martin Lagonda

The scheme has the endorsement and support of key agencies relating to Engineering education

*Engineers Employment Federation, Engineering and Marine Training Authority, Campaign to Promote Engineering, ImechE, Motorsports Industries Association,*

We were very pleased to be involved in the event as it fits in with the Campaign's message, i.e. showing young people that engineering is rewarding, exciting and very different from most peoples' perceptions. Watching the enthusiasm amongst the children and the adults at the event showed what can be done

George Willets. Campaign to Promote Engineering

# Kick-starting Engineering Excellence in Schools - Part 4

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## The wider picture - opportunities through other UK initiatives

### The Engineering Education Scheme

This scheme is not directly comparable with Formula Schools as it usually pulls from those already doing engineering based studies, rather than offering insight at an earlier age.

High calibre sixth form students from across England work for five to six months with companies on an in depth topical engineering problem.

The Scheme provides

- ⊙ Launch Day
- ⊙ University residential workshop
- ⊙ Celebration and Assessment Day

Students taking part have found it a very rewarding experience, of particular importance is the residential. If this is a well resourced and planned activity the students get a real insight in to professional and competitive engineering.

### The Denford Challenge

The focus of this event is to enable the use of CAD and CNC equipment in schools, and as such it is run by Denford (one of the major suppliers of this type of equipment into schools) and sponsored by Jaguar. Students design the shape of a body to be CNC routed from a block of balsa wood.

“CNC (Computer Numerically Controlled) Machines, such as the Denford MicroRouter, allow processed CAD drawings to be manufactured to high degrees of accuracy, fit and finish.”

Students then add wheels and are given a CO2 motor to attach before firing them down a 20-m cord, with the best time winning.

Teams compete against each other in a national championship to determine the best engineered and fastest car in the UK. Points are awarded in the following categories:

- |                          |                       |
|--------------------------|-----------------------|
| ⊙ Specification          | ⊙ Design Portfolio    |
| ⊙ Team Design            | ⊙ Use of CAD and ICT  |
| ⊙ Quality of Manufacture | ⊙ Verbal Presentation |
| ⊙ Time Trials            | ⊙ Reaction Times      |

Design concentrates on aerodynamics and surface finishing, although only limited hand finishing is allowed after CNC machining. Schools without access to equipment can use a local centre set up by Denford.

The context of motorsport seems to be arbitrary, as the range of materials and processing systems is limited to producing a balsa-wood aerodynamic shape.

### GreenPower

Full-size go-karts powered by two 12v batteries compete in an endurance race around a shortened track at Goodwood. The main objective of this project was to encourage the young students to compete in the race, which focused on a series of outcomes.

- ⊙ Fastest go-kart.
- ⊙ Best designed.
- ⊙ Highest number of laps without a battery change.
- ⊙ Best team

The project criteria set basic build guidelines, but the students were then able to use their initiative and imagination on the vehicle presentation and method of construction. Students participated in design, manufacture and construction activities and experience first hand a range of engineering technology.

- ⊙ Teams are made up of ten students taking turns in driving and acting as pit-stop mechanics
- ⊙ High focus on teamwork and the entire group were involved at every stage of the project.
- ⊙ Students felt they had a better understanding of engineering technology from the project.
- ⊙ Some students were keen to enter a career in engineering.

The major automotive vehicle and component parts manufacturers keenly sponsor the project.

This initiative certainly differed from the other projects in as much that it focused on life-size go-karts rather than models. Although this project gave the better design and build experience for the students there is of course the issue of storage. Vehicles of this scale tend to restrict GCSE projects to very few pupils due to the need for the work of individuals to be effectively assessed. Much could be made of the opportunities for general delivery by producing supporting curriculum resources.

## Kick-starting Engineering Excellence in Schools - Part 4

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### Is the UK on its own in not offering engineering to all in secondary education?

Research into the experiences of pupils in France and Germany suggests we are not alone in needing to engage the minds of future generations.

#### France

Pupils do not do a Technology subject in all schools, some may offer 'Travaux Manuels' as a craft option but it is not applied science or engineering. For most pupils they get the choice to select an academic or vocational route at 15 years old. A 'College Technique' course can be done in engineering leading to a Baccalaureate or a craft course aimed at persons who will aspire to manual trades.

The only topic where a near equivalent to Technology is taught in the age 12 – 15 is Physics.

Gilbert El Baz. Region Parisienn

#### Germany

In our school we get technical knowledge only in the subject "Physics". But even though, it is only this subject, where we get information, we get far more than basics in several areas. That means electronics, technology etc. too. In my class - to give you an example - everyone is building at the time a small electric motor. In the last two years we can specialize on the subject "Physics". There it is possible to get better information for instance about mechanical engineering. But if one searches a career in this area it is better to study it on university.

Rainer Hennig  
(16y, Hans-Sachs-Gymnasium Nürnberg, form 10a)



#### USA

Not an untypical e-mail from the Web site

'I am a student at Maranacook High School in Maine, USA. I am doing a project for my advanced physics class that is VERY similar to what you guys did in OPTO ELECTRONICS, project 3. Could you give me more specific details on how you made this? I have been searching forever trying to find how to make this, and it seems as though you have made exactly what I want to! Any help would be great. Thank you very much,'

Nick Robinson

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### Germany, More Lessons in Technology

The perspective of the Engineering Trade association

An interview by Die Zeit with Hubertus Christ of the Association of German Engineers (VDI)

#### *Industry is lacking young talent*

**Die Zeit:** Industry is complaining about a lack in engineers. According to a study carried out by the Institute of the German Economy only half as many electrical and constructional engineers will leave university in 2001 as compared to 1997. How do you explain this drop?

**Hubertus Christ:** Despite an enormous increase in turnover in constructional engineering, 16 per cent of staff were dismissed between 1988 to 1998. We see similar figures for electro-technics. This has deterred many a young person from taking up a technological course of study, despite the fact that engineers were less affected by dismissals. On the contrary, in this period 30 per cent more engineers were taken on, a fact, however, which industry failed to communicate. In the meantime, the figures for freshmen have been picking up again, yet in the years to come we will still face a shortage of experts. What is more, the demand for engineers in the economy is growing.

**Die Zeit:** Why didn't the associations call attention to the fact?

**Hubertus Christ:** The VDI held back because the job market is highly dependent on the business cycle. We didn't speak up until the drop in students became noticeable. We should have reacted earlier.

## Kick-starting Engineering Excellence in Schools - Part 4

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**Die Zeit:** Would a Green Card for engineers be the right way out of the new crisis in shortage of talent?

**Hubertus Christ:** The normal way would be to recruit more foreign students to our universities and offer them the possibility to stay on in the country for a few years after they finish their studies. Computer Sciences have been pushed too much. This implies the danger of having too many computer scientists in five years from now which will then trigger a new "pigs' cycle".

**Die Zeit:** According to a study done by the Academy for the Assessment of Technological Consequences, the insecure job prospects were not the only reason for the slackening interest in engineering-related subjects.

**Hubertus Christ:** Technology in schools gets short shrift. Natural sciences are taught far too theoretically. The practical reference is missing. Pupils don't know what to do with it. Physics and chemistry are among the least popular subjects.

**Die Zeit:** Should technology become a school subject?

**Hubertus Christ:** The VDI is arguing for an unintermittent teaching of technology from primary school all the way to secondary modern school. Schools have to rouse more interest and enthusiasm for technology. In particular with female pupils.

**Die Zeit:** On the one hand, engineers are desperately sought after, on the other hand, 55,000 are unemployed, primarily engineers above 45. Why don't you fall back on these?

**Hubertus Christ:** We have thought about how to use these unemployed engineers. We've offered them personal consulting and further education cost-free. We have arranged practical training in industry where the companies could decide after six months if they wanted to employ them on a fixed-salary basis. Most companies, however, have declined.

**Die Zeit:** Why?

**Hubertus Christ:** Those who for 20 years only do their work after they finish their studies and don't continue with further education are simply separated from the current level of knowledge. It is impossible to catch up with a single measure of further education. In the last years technological development has been rapid. Old technologies are no longer applied. In case engineers have specialised themselves and have only dealt with these old technologies they'll have to find an occupation in a completely different market.

**Die Zeit:** In how far do you see change?

**Hubertus Christ:** Also in the future a basic knowledge of natural sciences and technology will be indispensable. Although the service sector will become more important, a multitude of technical tasks are waiting. What is more, team spirit, communicative skills and social competence are becoming increasingly vital. As knowledge quickly becomes obsolete, teaching should be carried out in an exemplary manner only. Intricate and systematic thinking and acting are also becoming more significant.

**Die Zeit:** Globalisation also requires new qualifications.

**Hubertus Christ:** Due to worldwide co-operation, foreign languages and inter-cultural skills are becoming increasingly critical.

**Die Zeit:** That means that the image of the tinkerer is definitely one from the past?

**Hubertus Christ:** Among our engineers today we find communicators and managers who work globally. We also want to win people for engineering studies who have so far been more geared towards business studies or the humanities. But we'll continue to need specialists. Specialists, however, who are able to include their results in a team. Leaders must be translators of knowledge.

**Die Zeit:** 15<sup>th</sup> February 2001

## Conclusions

The evidence in this report clearly demonstrates the growing success of the Formula Schools scheme and its potential for further expansion. The positive feedback received from all the main stakeholders coupled with the needs of the engineering industry proves that there is a place for improving the delivery of engineering as a national curriculum subject. The scheme actively brings together education and business benefiting all and most importantly, raising the profile of engineering for young people.

Part of the evaluation exercise has been reporting on progress against the objectives set at the outset of the scheme. The scheme clearly promotes engineering in schools encouraging pupils to consider it as a possible career path. There is a direct correlation between the number of schools now offering engineering as a result of this participating in the scheme. An additional six schools now offer engineering as a specific curriculum subject. It is recognised that these objectives and the methods of measuring need to be reviewed as part of the scheme's development.

There have been thirty-five schools participating since the scheme's inception demonstrating a significant overall upward trend from only four years ago. The feedback from all the main stakeholders demonstrates the importance and effectiveness of the scheme. It is seen that pupils are given an excellent opportunity to learn technical and generic skills in an exciting and motivating team environment. Interestingly this responds to feedback from engineering companies reporting that some of the key skills they require from potential employees are generic skills such as team working, general communication skills and an enquiring mind, not solely technical ability. The scheme is holistic and has many outputs at different levels, such as:

- i) encouraging pupils to develop specialist-engineering and generic skills;
- ii) pupils can learn in a project team structure often liaising with businesses for support;
- iii) influencing educational government bodies to ensure that the national curriculum reflects the needs of the engineering employers;
- iv) impacting on the local and national economy;
- v) raising the profile of engineering and assisting in the career opportunities.

The latter point is confirmed by the Human Resources Manager, TWR Group, who states that,

*'I am certain that in a few years we will receive applications from engineers which include taking part in the scheme on their CV and which will give them a distinct advantage.'*

However, it is seen that the success of the scheme within the school can differ as there are different operational conditions. These can affect the way in which the scheme is managed within the school environment. For example, the scheme can be treated as an extra curriculum activity requiring extra resources with only limited time available.

The scheme has no direct costs for schools and deploys government agency funding benefiting both the education and business sectors. Schools can also raise additional funding through sponsorship providing further business experience to the pupils. One disadvantage is the annual funding cycle associated with government agencies.

The analysis of needs of the engineering industry and the current skills shortages support the need for raising the profile and increasing the time spent on engineering in schools. As quoted by a pupil at St Edmunds Girls School,

*'We would never have done any form of engineering if it had not been for this competition.'*

It is recognised that there are a number of issues concerned with the structure of the national curriculum linked to delivering engineering in schools. The subject is within the Design and Technology field which contains a choice of specialist subjects giving equal opportunities to girls and boys. In summary, the subjects, which contain the greatest amount of engineering skills, are the least popular options. Therefore to change this culture it is important to liaise with government educational bodies to remove some of these barriers.

## Kick-starting Engineering Excellence in Schools - Part 5

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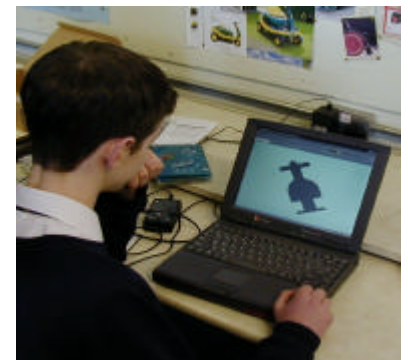
This holistic approach makes the Formula Schools scheme differ from other similar initiatives. For example, other initiatives have a more focused approach into one area of activity and do not offer the breadth of learning and experiences covered by this scheme. This can be demonstrated further by the combination of skills and knowledge offered, including areas such as opto-electronics providing the holistic approach to delivery of Technology to the young person.

**The analysis of the engineering studies in Europe demonstrates how similar concerns exist with the lack of young people going into engineering as a career.**

Some of the key facts supporting the conclusions are as follows:

### Key Facts

- ⊙ 20% of schools involved in Formula Schools now offer Engineering as a subject. This represents an engineering opportunity to every 14 year old in those schools; at present a cohort of some 1200 pupils per annum.
- ⊙ For all of them Formula Schools has been an influencing factor. For two it was the deciding factor.
- ⊙ Three of them now base the whole engineering course around Formula Schools
- ⊙ 60% of Oxfordshire's applied science and technology GNVQ curriculum is taught in Formula Schools centres.
- ⊙ 100 % pupil response when asked if they thought the scheme was worthwhile.
- ⊙ 80 % of pupils taking part thought there was career potential in the full range of engineering activity
- ⊙ Companies will support the scheme if it continues to deliver these outcomes
- ⊙ Directly addressing the needs of a technology based economy by working with schools comes with its own feel good factor. It also fits well with company PR profiles.
- ⊙ The need to keep up with curriculum delivery in schools is vital. The vocational GCSEs, soon to replace the GNVQ are one example of how Formula Schools must continue to keep up with delivery models.
- ⊙ A process of osmosis has led to expansion of the scheme rather than strategy
- ⊙ Formula Schools is a proven framework to take forwards
- ⊙ The scheme has suffered from being too localised and has not been able to attain the wider impact it can achieve
- ⊙ A wider audience has always been there but the delivery system has not.
- ⊙ This can be balanced by the quality that now exists through its long developmental time as a regional scheme.
- ⊙ Care needs to be taken to retain the primary aims and ethos of the scheme.



## Recommendations

Key recommendations from this report are as follows:

- ⊙ There is a significant amount of evidence to support the continuation of the scheme and look to develop the opportunities further;
- ⊙ The scheme has been mainly based in Oxfordshire, but other regions could be involved;
- ⊙ The future structure of the scheme must reflect the growing needs and ensure that the local dimension to the scheme is maintained. A suggested structure reflecting key roles and responsibilities is shown on the following page;
- ⊙ The expansion plans must be managed from a central source ensuring the focus is maintained and core functions are centrally controlled, e.g. that an effective marketing package is developed to both promote and explain the ethos of the scheme
- ⊙ A support mechanism is required to assist schools in getting the full benefits from the scheme, e.g. help in obtaining maximum additional funding and links with employers;
- ⊙ New objectives reflecting the immediate and long term nature of the scheme should be compiled;
- ⊙ It is essential that an appropriate infrastructure be adequately funded to ensure that the quality is maintained.
- ⊙ A support pack should be produced to assist the cascading of best practice, e.g. the use of older pupils as mentors to supplement skills and knowledge delivery.
- ⊙ To actively seek out the involvement of girls, by encouraging entry from girls schools and more even gender distribution within mixed centres.

# Kick-starting Engineering Excellence in Schools - Part 5

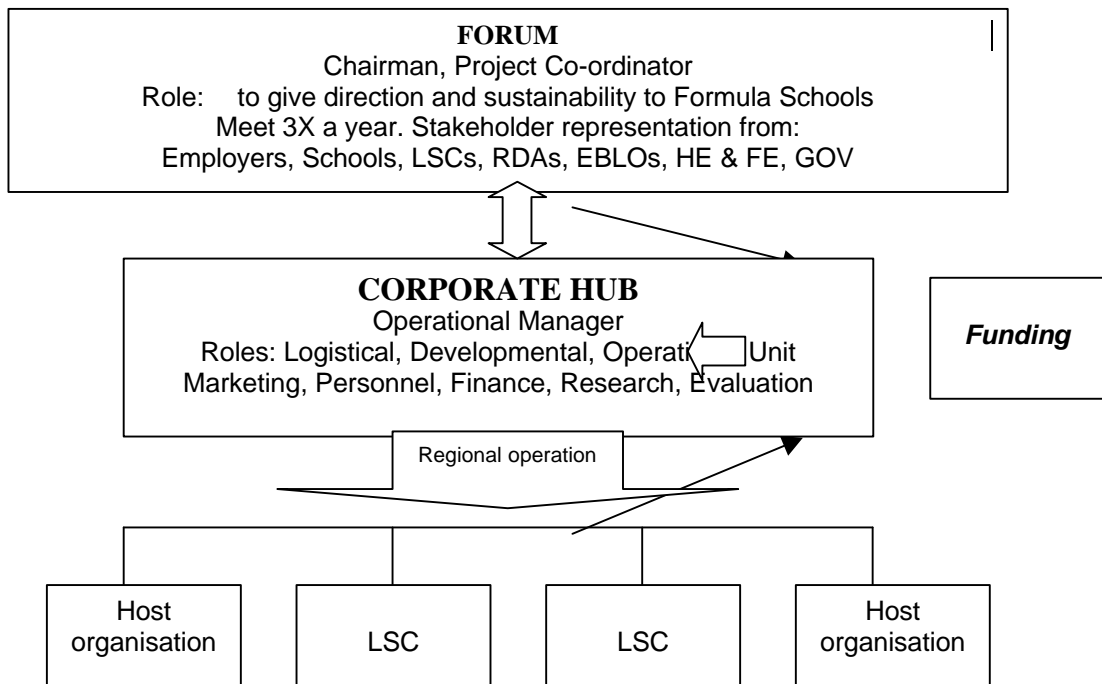
## A Proposed Structure for Formula Schools

### Background

The structure is based upon:

- **Philosophy of the project**
  - Changing the experience the young have of applied science and technology in secondary education. Increase opportunity and uptake of engineering in schools
  - Importance of changing the mind sets of pupils regarding education and employment in Engineering
  - Bottom up approach Local Flexible
- **Hopes and Fears of project**
  - Hopes**
    - To develop and sustain a quality project.
    - Raising the quality and popularity of the Applied Science, Technology, Engineering experience and curriculum in schools and colleges.
  - Fears**
    - Will become a political football
    - Will lose its direction without the right minded people with specialist skills delivering into education and industry
    - Will become like so many other schemes, imposed from the outside, leading to a loss of direction.
- **Principles of the scheme**
  - Pupil and teacher led, minimum administration, maximum operational
  - 'Local' in terms of linking with and serving local needs
  - Still retain the power to influence at a national level

### Structure



# Kick-starting Engineering Excellence in Schools - Part 5

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**Contributions from the following have been included in this report**

## **Schools**

All schools in the Formula Schools challenge  
All schools dropping out of the challenge over the last four years  
Selection of schools unfamiliar with the scheme  
Case study schools in Europe: Stuttgart, Paris

## **Further Education**

Rycotewood College  
Myerscough College

## **Higher Education**

Oxford Brookes University  
Cranfield University  
University of Hertfordshire

## **Motorsport and other Engineering companies**

AML  
Benetton Formula Ltd  
British American Racing  
Caterham Cars  
DSPA Dave Williamson  
E<sup>2</sup> Engineering  
Irvine Ltd  
Jaguar Racing  
Jordan Grand Prix  
Lincoln Electric  
Reynard Motorsport Ltd  
Prodrive  
Swan foundry  
Transense  
TWR Group  
TWR Arrows  
Williams F1 Ltd  
UKEA

## **Organisations**

CPE	Campaign to Promote Engineering
DFEE	Department for Education and Employment
Education and Youth	
EEF	Engineering Employers Federation
EMTA	Engineering and Marine Training Authority
ImechE	Institution of Mechanical Engineers
Local Education Authorities	OXON, WARWICKS, NORTHANTS, WILTS
MIA	Motorsport Industry Association

## **Publications**

DFEE:	
An assessment of skills needs in Engineering	Autumn 2000
EEF	
Introducing Engineering in Schools	Spring 2000
MIA	
The National Survey of Motorsport Engineering and Services	Winter 2000
AQA, OCR. (Assessment and Qualifications Alliance) (Oxford, Cambridge, RSA )	
Examination reports and results	1998, 1999, 2000

## **Kick-starting Engineering Excellence in Schools - Part 5**

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