TECHNOLOGY INNOVATION AND SOCIETY

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Foundation's logo gets a new look

In the early 1980s, when the Foundation first established itself with the working arm of 'The London Science Centre', it was felt that there should be a logo. The London Science Centre was, of course, to be a base, or shared home, for smaller learned societies wishing to benefit from the shared facilities which would be offered. The Foundation stopped acting as a centre with accommodation after about two-and-a-half years, and by the mid-1980s it was felt that the term Science Centre was inappropriate, so the charity's own name was used from then on.

The first logo was created when it was the London Science Centre. One of the daughters of the Earl of Shannon (then Chairman) designed a simple logo to include the initials LSC, the *L* being bent into an angle (fig. 1). It first appeared on the fifth issue of the Learned Societies' Newsletter in October 1982.

Learned societies became familiar with this logo, and the general shape seemed to mean something, so when the Foundation dropped the name of the working arm, it wanted to keep something of the general shape. In April 1989 the Learned Societies' Newsletter adopted a new logo designed by Austin Knight (fig. 2). This shows that the basic shape of the bent *L* was retained, and this appears on the front of publications such as the Journal and the Register of Learned and Professional Societies. Of course, there was no secret behind the shape, though some might have thought there was! What did the shape represent - a nose, a microscope, a sailing boat sailing into the future? There were many ideas, and all were right. There was no official answer.

In 1995 it was felt that the Foundation should look again at its promotional material and bring its leaflet up to date. It was then that we approached Sebastian Conran through a member of Council, and he was asked to have a look at the logo to see if it could be improved, perhaps made more positive and complete.

Sebastian Conran and his colleague Selina Fellows attended a lecture and dinner discussion, and ideas started to flow.

By the end of the evening the double helix was firmly in their minds, and a copy of the front of his programme for 15 November 1995 (fig. 4) shows their minds at work, and some of the ideas that are reflected in the revised design now used by the Foundation. The result for the logo is at fig. 3. The Foundation therefore still retains something of the first logo, the bent *L*, and it never ceases to cause comment.

Young scientists and engineers share their vision

On 2 April 1996 six young scientists and engineers gave short presentations to an audience of over 150.

Each in eight minutes described the highlights of their career, their aspirations and what they felt about their education and their life in science or engineering.

Those speakers were Dr Tracey Turner from Darebury Laboratory; Dr Mark Cliverd from the British Antarctic Survey; Rickard Andersson from John Brown plc; Adrian Colyer from IBM Laboratories; Alexandra Walker from the Ford Motor Company; and Dr Steve Young from Glaxo Wellcome Medicines Research Centre. Professor Sir Robert May, the Chief Scientific Adviser, introduced the evening.

The event marks a move of the Foundation's Council to attract some younger people to its events, and recently a number of the Associate members have either brought younger engineers or scientists to the evening events, or been represented by them.

Promotional material has a Conran makeover

The Foundation's logo, the promotional leaflet and the evening event programme covers have been redesigned by Sebastian Conran Product Identity Design. The story of the logo appears above. Sebastian Conran and Selina Fellows came to an event during which they hoped to gather some ideas for the redesign, at the same time getting a feeling for the Foundation and its activities. Their minds and imaginations soon became extremely productive, and Sebastian's pencil sketches and themes on his copy of the evening's programme became the basis for development. He felt that a theme could be based on the helix or the double helix, representing science, e.g. DNA, and also engineering (the spring). The material is now in use.

Learned Society activities

By the end of July the Foundation will have organized eight seminars and workshops for learned societies. The most important was the seminar on the new accounting regimes following the publication of the Home Office Regulations and the Charity Commission's guidance on charity accounts through the Statement of Recommended Practice (SORP 2), bringing with them the new Statement of Financial Activities, which, in many cases, will replace the Income and Expenditure account.

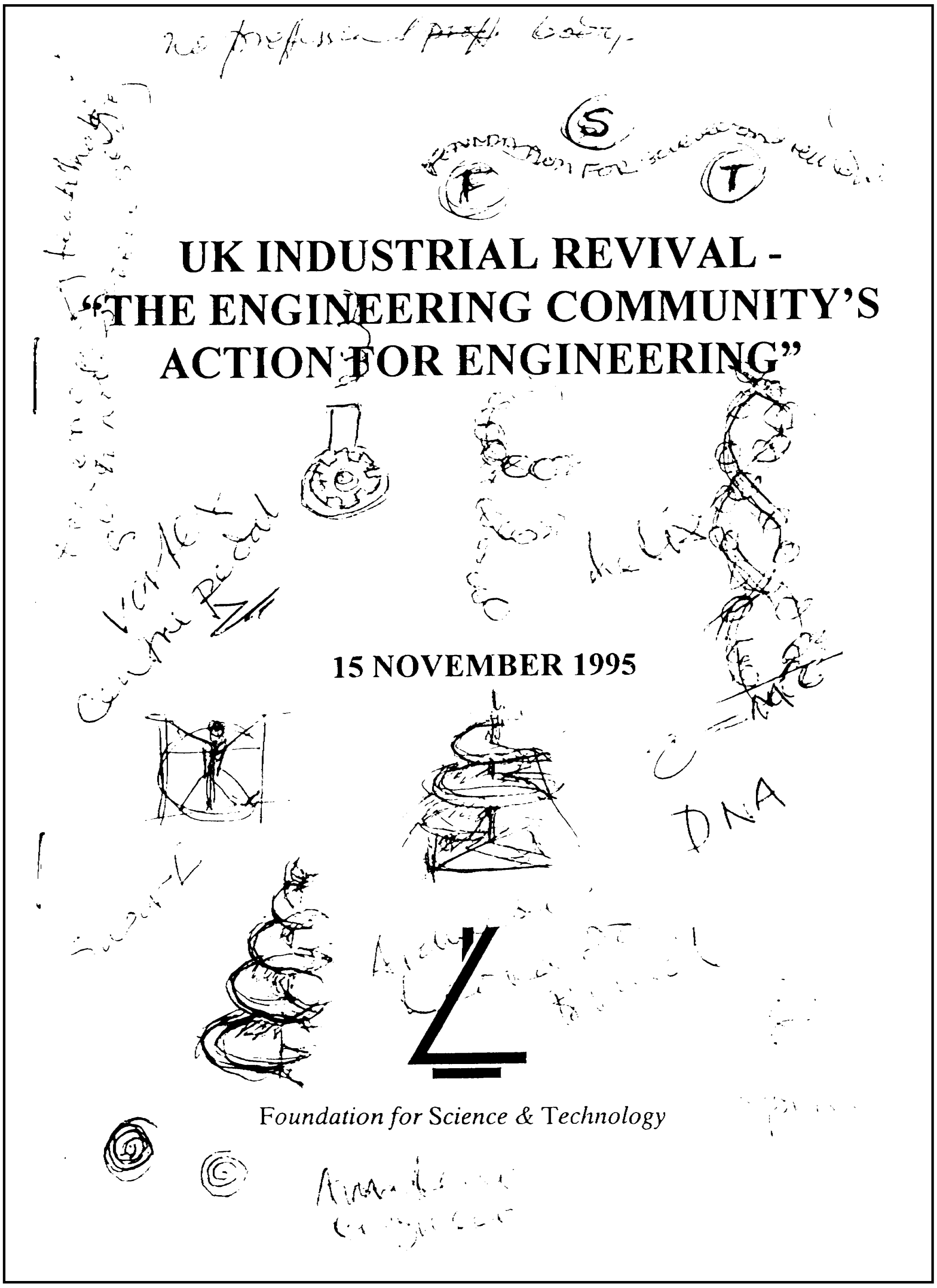
The most popular event for learned societies was the seminar on the Internet which the Foundation organized jointly with the Association of Learned and Professional Society Publishers, and held in the huge theatre of the Royal Geographical Society. Over 130 heard case studies to show how some learned societies were making immense use of the Internet, and Professor Bernard Donovan, the General Secretary of ALPSP, gave the last talk, bringing the future into perspective. So important was that talk that it is published in this Journal (see p18) as well as in the Learned Societies' Newsletter.

New Associate Members

Japan Society for the Promotion of Science
Representative: Professor Yasuhiro Shiraki
British Standards Institution
Representative: Chief Executive
Cancer Research Campaign Technology Limited
Representative: Dr Susan E. Foden
Brunel University
Representative: Professor M.J.H Sterling, F.Eng
Research into Ageing
Representative: Mrs Elizabeth Mills
Sebastian Conran Product Identity Design
Representative: Selina Fellows

More news in pictures – see page 17

…and the doodles that led to a polished design



◀ *Figure 4: 'Doodles' that show a designer's mind at work. Sebastian Conran went to a Foundation event to gather ideas and pencilled in sketches and possible themes on his copy of the evening's programme, shown here.*

DEVELOPING IDENTITY: HOW FOUNDATION HAS MADE ITS MARK

▲ *Figure 1: The original logo from the London Science Centre days.*

▲ *Figure 2: Austin Knight's 1989 update kept the distinctive bent 'L'.*

FOUNDATION
for SCIENCE and
TECHNOLOGY

▲ *Figure 3: Logo by Sebastian Conran Product Identity Design - and that 'L' is still there.*

WHAT IS THE PLACE OF MATHS AND SCIENCE?

The Foundation held a lecture and dinner discussion at the Royal Society on 1 November 1995 on the subject 'Education and Employment: What is the Place of Maths and Science?' under the chairmanship of the Lord Butterworth, CBE, DL. The evening was sponsored by Esso UK plc and contributors to the Foundation's Shared Sponsorship Scheme, including 3i Group plc, Biwater Ltd, Comino Foundation, Esso UK plc, Glaxo Wellcome plc and Zeneca Group plc. The speakers were *the Lord Henley*, Minister of State for Education and Employment; *Professor Julia Higgins, FRS*, Department of Chemical Engineering, Imperial College; and *Mr Martin Tims*, Manager, Education and Environment Programmes, Esso UK plc.

The Lord Henley*

Summary: **The Lord Henley argued that it was not the case that there had been a significant decrease in the number of young people studying science and maths post-16; it was the proportion that were studying science and maths only. More had to be learnt about why young people were not taking up science and maths; perhaps incentives were lacking. Professor Higgins pointed out that over the past 30 years or so a constant figure of only 5% of 16-year-olds had taken up three science subjects at A-level. There was also the fact that a disappointingly low number of girls opted to do science. Part of the problem, she suggested, was that many teachers lacked confidence in science and maths. There was also a lack of incentive related to salaries. Mr Tims said industry needed basic science and mathematics skills; newly-qualified teachers should have some sort of science and maths qualification; and the public needed a better understanding of science and maths.**

Introduction

I am pleased to have the opportunity to address the Foundation for Science and Technology because this is an opportune time for us to be talking about maths and science education. Obviously I want to make the Government case but I also want to hear from you about how we can improve in both quality and quantity.

That is obviously the Government's aim. And it is critical to our future. High-quality education - in maths and science and generally - is vital to our ability to compete in the global market-place. With the increasing international mobility of capital, the success of an economy depends increasingly on the value that can be added by its workhorse. We can only achieve high added value with high quality education.

This is not just about economics but also about our well-being as a society. Scientific and technological advance inevitably means that there will be fewer unskilled jobs. Those jobs will be increasingly concentrated in parts of the world where labour is cheap. In this country it will become increasingly difficult to get a job without first getting a good education. Without a job it is difficult to play a full part in society. There is a danger of alienation and all that follows.

So, we believe that education and training are the keys that open the door to a successful economy and all that goes with it.

The merger of the departments of education and employment has brought the promise of a much more integrated approach to the issues which unite education, training and employment. Its main purpose is to bring together policies and programmes for a skilled and highly qualified workforce, and a flexible, efficient and deregulated labour market.

Some of the greatest benefits of the merger will, I believe, be seen in our capacity to foster links between the final years of compulsory schools and continued education and training, both within the FE sector and at the workplace. We need to build on what has already been achieved. Making the 14-19 continuum a reality - and looking beyond, to lifetime learning.

There has been little short of a revolution in education in this country over the last five to ten years. Certainly for one who was on a LEA seven years ago to return to education in July of this year, the changes have been dramatic.

The National Curriculum

At the heart of our drive on standards is the National Curriculum and the associated assessment and testing arrangements. The principle of the National Curriculum is now almost universally accepted. Indeed, it is a measure of how far we have come since the 1988 Education Reform Act that it is almost unbelievable that there was just a short time ago practically no national agreement on what should be taught in schools. For too many pupils that meant there was very little science and no technology in primary school; and it meant that far too many pupils, particularly girls, dropped science altogether at age 14. Both subjects are now compulsory for all pupils from 5 to 16 as part of a national entitlement to education for every child in this country regardless of their background or where they live.

As well as providing minimum standards, schools should also have the freedom to play to their strengths and to meet the particular needs of the communities they serve. That is why we have made it a particular priority to encourage schools specialising in science, technology and mathematics. The Technology Colleges Initiative builds on our experience of the City Technology Colleges programme. The first twelve schools to win Technology College status were announced at the end of February 1994. The number has now risen to 101. They have each made a commitment to develop their teaching of science, technology and mathematics. They will introduce a wider range of opportunities for their pupils in these subjects. And they will expect more of their pupils to study them in greater depth.

Choice and diversity will also be fostered by the changes that have been introduced this term to the National Curriculum following Sir Ron Dearing's review. The new curriculum will release about one day a week for use at teachers' discretion.

For 14- to 16-year-olds there are fewer compulsory subjects, leaving about 40% of time for teachers to develop a range of vocational and academic options tailored to their pupils' abilities and aptitudes.

We have also promised, when introducing the new National Curriculum, that there will now be a period of five years in which we will not make further significant changes. We can use

* *Minister of State for Education and Employment*

that time to think carefully through the questions which still remain about the appropriateness of the science and maths curricula (without being rushed into solutions). None of these questions is the main theme of our discussions this evening. Are we persuading enough young people to continue their studies of science and mathematics beyond the age of 16? If we are not, what can we do about it?

Defining the problem

We ought to begin by getting the facts clear and by defining the problem – if there is a problem – more precisely. As to the problem: I think we need to distinguish three different areas in which there might be cause for concern:

First, are we getting enough young scientists and engineers?

Secondly, are we, more generally, getting enough at all levels of ability?

And thirdly, are we getting enough people who have at least some understanding of science?

As to the facts, it is important to remember that it is *not* the case that there has been a significant decrease in the number of young people studying science and maths post-16. First, the proportion of young people choosing to study A-levels has been increasing rapidly, but the proportion choosing to study science/maths has not. Secondly, there is an increasing tendency for students to do a mixed bag at A-level – 1 science and 2 arts, or 2 science and 1 art. So the proportion of young people who are studying science/maths only is dropping.

If you ask the question: does this matter? you get a variety of responses. Science-based industry – say pharmaceuticals and the chemical industry – will tell you that these two sectors depend critically upon a supply of top-quality scientists. On the other hand, if you look at the salaries paid to scientists in commerce and industry you don't get the impression that they are in short supply. An able and ambitious young man or woman will see many prospects which are financially much more attractive than a career in science or engineering. We in Government cannot force able young people into scientific careers if the outside world offers them no incentives. If industry fears a shortage it has at least part of the solution in its own hands – or rather pockets?

And I should add that I hope industry is looking far enough ahead. One obviously cannot turn the supply of scientists on like a tap if a shortage does develop.

Now all of this relates also, of course, to the well-known fact that the many top posts in British industry are occupied by lawyers and accountants, whereas in Japan and Germany a higher proportion are occupied by scientists and engineers. This is both a disincentive and, possibly, a serious structural weakness.

In this respect the rapidly growing popularity of mixed A-level courses – part science, part arts – to which I referred earlier, is welcome. It means that a higher proportion of our most able young people will be able to straddle the arts/science fence.

What I have been saying may suggest that I do not see much of a problem. That is not so. What I want to suggest is that we are talking about a pretty complex array of questions. And also that the Government cannot, on its own, provide all the solutions. But I do believe that we need to know why the numbers of science/maths students are not rising, and to consider what we can do about it.

The incentive structure

We have already talked about one possible contributory factor: the incentive structure at work. But basically we do not know enough about what persuades young people to decide which course to pursue. I very much welcome therefore the study which the School Curriculum and Assessment Authority has launched. They are looking at schools which have a high proportion of students going into science post-16, with a view to identifying their characteristics. This will be very useful basic work. But I think we can already guess at some of these characteristics.

Inspiring teaching must be one of them. So many scientists have said that it was teaching of exceptional quality which awakened their interest. There are a lot of things going on in this area which can give us hope. The Institute of Physics has an initiative in A-level physics which is very welcome. The CREST Awards, the development of courses such as the Salters' Course in chemistry, and the work of the Clifton Trust in giving youngsters an opportunity to participate in research, are other examples. And I think our five-year moratorium on change should encourage a concentration on the quality of delivery. I very much hope that, during these five years, there will be other initiatives, aimed at improving the quality and the attractiveness of science teaching.

There is another possible contributory factor (to disincentive to do science). That is difficulty. Studies at Newcastle University provide evidence that A-levels in science and mathematics are amongst the most difficult. This is something which has been suspected for a long time. Now this is potentially a pretty controversial area, and I do not propose to do more than offer one or two observations.

First, this perceived, and possibly real, difference in level of difficulty does not appear to deter the most able. But it may well affect the choices of young people who feel that A-levels, in any subject, are going to be difficult, and who do not want to put themselves at risk by choosing difficult options.

Secondly, we should not pretend that it would be easy to iron out these levels of difficulty. Making A-level science easier would provoke howls of protest from the universities. And making other subjects more difficult is really not on, when you are trying to persuade more young people to stay in full-time education. And I haven't even touched upon the question of how you deal with continuity of standards.

Thirdly, part of the solution may lie in looking harder at how children learn science and mathematics, and at the problem of ensuring that their mathematical understanding is sufficient to support their scientific studies.

Another matter we may need to look at is the nature of the science course at key stage 4, ie aged 14-16. Here there is controversy over whether the double-award course, taken by nearly all pupils, is a sufficient preparation for A-level study. Most people say that it is, but there is a sizeable, and vocal, minority which disagrees. This is part of a larger argument over what sorts of science course should be available at key stage 4. Should there be more flexibility, should we offer a greater variety of courses, courses for the future specialist, course for a well informed layman, vocational courses, and so on.

We want to see these problems argued out. But I honestly don't think we should be rushing into changes. Above all, we need to bear in mind that from 1998 onwards children aged 14 will have studied science continuously from the age of 5. They may have quite different capabilities, and quite different needs, from the present generation of 14-year-olds. We shall not know until 1998.

Also, it is particularly appropriate tonight, while we are enjoying the hospitality of the Royal Society, to bear in mind the Royal Society's own view. That is, that a return to three separate GCSEs carries the risk of over-specialization. I give some weight to this argument, particularly when applied to the most able pupils. We want them to be well-educated citizens, as well as good scientists.

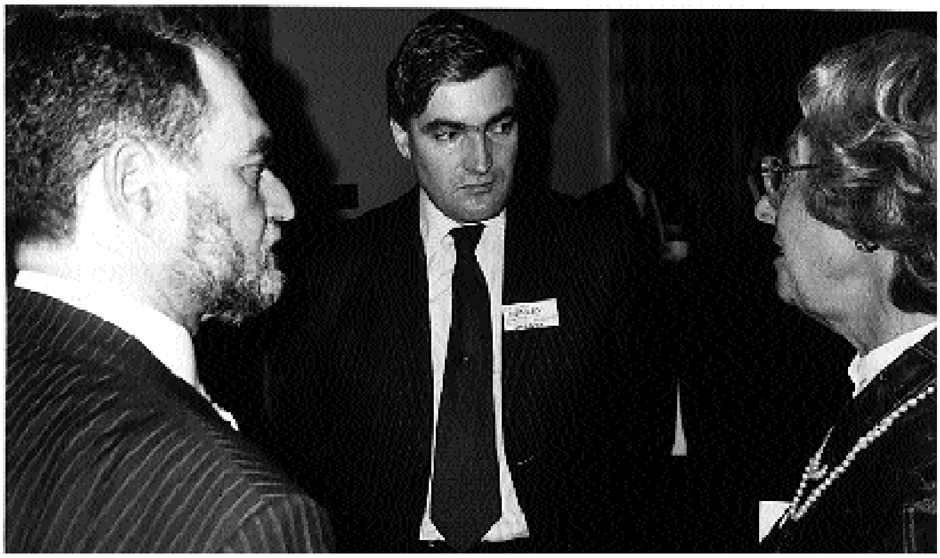
Finally, we need to look at the rapid development of alternative means of access to further and higher education in science and mathematics offered through NVQs and GNVQs.

GNVQ science is still relatively unpopular – 5,000 enrolments in 1994/95 compared with ten times as many for business studies. The evidence is, however, that students find the courses interesting and challenging, and that they encourage an approach to the acquisition of learning which will serve them well in work and in higher levels of education. Prospects for transfer from GNVQ into higher education are good. 92% of GNVQ applicants were successful this year - a higher rate than for candidates taking A-levels.

Conclusion

This has been a rapid and discursive skate over the surface of a lot of questions. I am also conscious that you may feel it odd that I have not discussed the review which Sir Ron Dearing is carrying out of 16-19 qualifications. My reason is simple: I prefer to wait until he has produced his report. It will probably be worth several lectures to itself.

Nor have I mentioned the London Mathematical Society Report on mathematics in schools - which has received much coverage and many knee-jerk reactions. I would prefer to consider it in due course. Nevertheless, I hope that what I have said may help to stimulate our discussions later in the evening.



▲ *The Lord Henley, Minister of State for Education and Employment, with (left) Mr Martin Tims, Manager, Education and Environmental Programmes, Esso UK plc, and the Baroness Platt of Writtle at the event at the Royal Society.*

Professor Julia Higgins FRS*

Introduction

I am of course a scientist and an engineer and so I tried not, tonight, simply to speak from prejudice but to look at some of the facts. I looked at a number of reports that had been published recently and I will mention them to you shortly, not least the one by the London Mathematical Society which appeared this week.

The first piece of information that I looked at was a figure from a report from the Engineering Council on the impact of double science at GCSE. The authors were talking about some of the consequences of the double science option and other variants in the curriculum at the moment. The figure shows for the last five years the percentage of the age group at 16 who take A-levels compared to those who take three sciences. The thing that struck me about it was not, as the Minister said earlier, that the numbers taking science relative to the other A-level students were not going up, but the extraordinary constancy of the percentage of the population at age 16 that had been choosing to do three subjects in A-level science and maths. It is quite amazing that over the last 30-odd years 5% of the population - and only 5% - has felt confident enough to take up doing three science subjects at A-level.

It seemed to me that this was a good starting point for thinking about the problem, if there is a problem. Of course the first stage, as Lord Henley said, is to ask the question ‘does it matter?’ It has been constant for so long that maybe it is a generic factor in the population of this country. All sorts of things have happened to education during that period. We had the change to comprehensive education. We have had the introduction of Nuffield Science, we have had the expansion of higher education, we have had the National Curriculum, the introduction of GCSEs, and the A-level three sciences have gone merrily on through all that at 5% of the available population. It is a remarkably constant factor.

Need for a basic science education

Does it matter? Well, it seems to me that it matters for two reasons. First, because I would like to see the very best people doing science and engineering. I think there is some evidence from industry, and Lord Henley touched on this, that we may have enough people specializing in science and engineering if you look at it as a global question of numbers. On the other hand, all of the industry that I talk to say that they do not have enough of the best. The best are not always good enough, and there are not enough of them.

I find it difficult to believe that a self-selecting group at age 15 or 16 necessarily includes all those people who would be very good at science and engineering. However, by choosing not to do scientific and engineering subjects at that age young people are opting themselves out of subsequently studying those subjects. That seems to me to be a pity. I would like to see more people carrying on doing science and engineering in order that the very best finish up as the professional scientists and engineers of this country. Second, I would like to see the whole population not only literate, but also numerate and knowledgeable to some extent about what is the basis of science and engineering. It seems to me that we have a lot of decisions to make as a population arising out of technological revolution and things that are going on in medicine and biology (genetic engineering for example) and without a basic scientific education it is difficult to make those decisions. I think there have been considerable advances in raising the knowledge and understanding of students up to age 16 doing science, but I believe that it is a pity that as it currently stands at least 50% of the population completely drop science and mathematics at age 16 and do no more. If you look at the numbers, about 10% of the people doing A-levels are doing science and mathematics subjects and something under 30% are doing mixed science and arts subjects. The latter are an increasing number and I am glad to see it.

Hidden in that number is another sad factor which I personally am very worried by, and that is the relatively small number of girls that chose to do A-level sciences. This is a number that has not been increasing, at least not in the hard sciences. In fact,

* *Department of Chemical Engineering, Imperial College*

▲ *Dr Michael Elves (left), Director, Scientific & Educational Affairs, Glaxo Wellcome plc, discusses a point with Mr David Moorhouse, Chief Executive, John Brown Engineering & Construction.*

in physics the numbers have started to go down again. There are three-and-a-half times more boys doing A-level physics than there are girls, and that from a basis where, as far as I know, equal numbers of girls and boys do well in their GCSEs. So although girls are coming up to a certain level, they are still opting out of doing the scientific subjects and therefore carrying them through to a career. The consequence of this is that at a place like Imperial College which is Science- and Engineering- and Medicine-based, only 16% of our engineers and only 35% of the scientists are women, and these latter include the medical and biological sciences which run at about 50/50. Just as a matter of interest, while we have 16% engineers at IC, only 13% of the numbers that apply are women, so we actually do rather well for women who apply to the college.

It does seem to me that those two factors, the small number of people opting to do science and mathematics and then, within that, the disappointingly low number of girls opting to do science, deserves some attention. I think, returning to my first question, I would argue that there is a problem and that we should look at it carefully.

The extraordinary consistency of the 5% figure for those choosing three sciences at A-level does suggest there might be something generic in the English Education System. I say the English, because the figures refer to English schools, not to the Scottish school system, which I think would produce somewhat different figures. The report from which I took the figure by the Engineering Council, called *The Impact of Double Science*, proceeded to make some suggestions about the cause, and focused on three factors that have already essentially been mentioned by Lord Henley. The first one was the teaching (particularly mathematics) at the primary school and at the junior school level. The second was the question of incentives and the third one, the question of the three subject A-level. I would like to deal with those three in turn.

Mathematics

I shall start with mathematics. Many of the people I spoke to, when I talked about the subject of tonight's discussion and asked what sort of message they would like to see put over, said the one single thing that makes it difficult for students to choose to do scientific subjects at age 16 is an uncertainty about their mathematical ability. If we could only give young people confidence in mathematics we would open their choices in science subjects; they perceive the subjects as hard because they perceive them as mathematical. Therefore attention to the way we teach mathematics will have a knock-on effect as to whether pupils will or will not choose to do scientific subjects.

Which brings me to the second report which I looked at. This was the report published last year from OFSTED on Mathematics in the Schools. There were many interesting points brought up by that report and I clearly cannot go into all of them tonight, but I would like to quote you one little paragraph which came from that, talking about maths teaching, which I think is the key to all of this. It says:

> New recruits [and I put in brackets 'to maths teaching in primary schools' because that was the heading of the paragraph] are no longer pathologically frightened of mathematics but competence is no substitute for the enthusiasm which comes from complete mastery.

I do really think that if we look at the people who take on the job of teaching in our primary and junior schools, which is a very hard job, many of them are not confident in mathematics. They do not have a background that gives them that confidence and therefore it is very hard for me to see how they can convey a sense of the joy and pleasure of being able to master mathematics to their pupils. The OFSTED report went on to suggest therefore, among many other things, particular attention to improving the quality of maths in primary schools. One of the suggestions they made was that some schools have introduced mathematics co-ordinators who work alongside the class teachers. Schools can have specialist maths teachers without requiring that every teacher in the junior school is such a specialist. That seemed to me a helpful idea although of course it costs money. The report also, of course, focused on the question of encouraging high-quality teachers into mathematics and science, and given that a good graduate in maths and science or engineering from university still has many options in terms of the job market, I do believe that there is a serious deficiency in the number of high-quality teachers.

I have also, to be prejudiced, observed the teaching that my nieces and nephews have been subjected to and it is very patchy. Even in very good schools, there are many teachers who seem to lack this confidence that we are talking about, both in maths and science, and therefore fail to convey the confidence to their students. Of course, we have already referred to the report from the London Mathematical Society and others. This report is really focusing from the higher education end on what we, the universities, are receiving in terms of the incoming students in science and engineering and the problems we are facing. I find it very helpful because what it actually has done is to put clothes on a skeleton of local and anecdotal information that I and others have from one end of the education market. I should point out that the average in A-level scores for our students at Imperial College coming into engineering are 25 or 26 points. One of our Departments, Electrical Engineering, is averaging 29 points at A-level. This is enormously high. We do not take students into our engineering departments with A-level Mathematics below a C grade and most have an A or B. So we are taking the top mathematics students from A-level and we are perceiving the same problems with them which have been identified in the report. Of course, the best are still extraordinarily good and the ones who are confident are still doing brilliantly, but there are a growing number who suffer from the problems identified in this report.

Of the three major problems which are identified, the first one is a serious lack of technical fluency. By that the Society means the ability to carry out numerical and algebraic manipulation. Many of the people who have done mathematics are not

> More and more students... have extraordinary difficulty in dealing with a problem which does not look like one they have seen before. They appear to have been taught to jump through hoops very satisfactorily so long as the hoop is the same shape, the same size and the same colour as it was last time

as good as they were before at doing that. I suspect that is not such a big problem for the ones that we are teaching at Imperial, the ones at the top level. But the second problem that is noted is a marked decline in the ability of students to solve problems involving more than one step, and I would add to that 'problems they have not seen before'. We seem to be seeing more and more students - it is still a minority but it is a noticeable minority of students - who have extraordinary difficulty in dealing with a problem which does not look like one they have seen before. They appear to have been taught to jump through hoops very satisfactorily so long as the hoop is the same shape, the same size and the same colour as it was last time.

Just to digress into mathematics, for those of us here who deal with it, students are able to deal with dy/dx in calculus but if you happen to mention it might be du/dv, horror appears on their faces. This is not totally a joke, it is actually a problem. Therefore something appears to have happened in mathematics teaching which is over and above the problems we have already identified which may lead to students lacking confidence and therefore not choosing science. Students do not appear to have some of the abilities that they had before and one then has to look around for the causes.

The report of the Mathematical Society here identifies some of the causes of the problem and suggests these are to do with some of the changes that have taken place in the maths curriculum and the amount of time allowed for mathematics teaching. I am not an expert in the curriculum and I only saw the report yesterday so I do not propose to go into the details. I do strongly support demand for urgent attention to be paid to what is going on in maths teaching and why those who are emerging with apparently the same A-level grades do not appear to be able to do what they could do a few years ago.

It might be said by some people, 'why do the universities not do something about it?' and of course we do. We look very carefully, in Imperial, for those students who might be having problems and we help them. We give them extra mathematics help, but that of course is very difficult if 70% of the class is still competent and you try to teach the other 30% something extra. You cannot ask the 70% to stand still, and if you do not, then the 30% have got even more to catch up on later, which causes further problems. I would also maintain that it would be better not to have taught people something than to have taught them to do something poorly or without confidence. It is actually harder to 'unteach' something and 'reteach' it than to teach it from scratch.

Personally I think I would rather receive students in the universities going into science and engineering with a very firm grasp and confidence in a core amount of mathematics. I include both the sciences that support the main engineering subjects, which are usually physics and chemistry. I would say that a firm grasp of the core would greatly facilitate our job even if that necessarily may lead to narrowing the subjects covered. I would plead most strongly that the core is the same for each student. To have a proliferating number of different A-levels with different syllabi and options within them means, for example, that we are teaching sets of students, some of whom have never heard of vectors and some of whom have never heard of certain trigonometric manipulations. The result is that we actually have to spend time teaching everybody something different. It would be much better if we had a clear view nationally of what constitutes the core and we stuck to it. I think I have probably said enough about mathematics for you to realise that I do see it as the key to being confident and competent in science and engineering. However, that cannot be, I believe, the only reason why students are not going into the sciences and engineering, the only cause of this 5% figure.

Incentives

The second question raised by the Engineering Council was about incentives. There is an interesting point here which was not brought out in Lord Henley's speech. If you think of places at university being available as an incentive to students to study a subject then you ought to argue that three science subjects at A-level form an obvious choice because, since the increase of the number of places at university has been roughly parallel in the sciences and the arts there is therefore, given the increased number of people doing the arts, much greater competition for the places in the arts faculties than there are for the places in the science faculties. It seems strange that even with that incentive the students are not choosing to do the A-level science subjects.

There is also the question of employment and I would agree very firmly that if industry wants more very good engineers and scientists it certainly should be paying for them. It is an interesting question because it is very difficult to get clear factual evidence. It is said that scientists and engineers are no less likely to be unemployed than arts graduates. But I think that is a general statement, and needs closer attention to see exactly what it means. It is said that the top salaries are not paid to scientists and engineers and it is certainly true that choosing to be a medical consultant or a lawyer (dare I say it) results in a far greater salary than being a university professor, or even I suspect a Research Manager in a medium-sized company, though I would be open to correction on this.

Three-subject A-level

The third area that the Engineering Council pointed to was the three-subject A-level and it has seemed to me for a long time this is something we should examine closely. I have worked abroad in France and I have travelled extensively in Europe and the USA. I think the USA educational system is so different from ours that it does not provide useful parallels, but if one looks at the rest of Europe, it is quite interesting that, particularly in France, with its Baccalaureate system, I detect many more women in science than I do in this country, which involves doing a broader range of subjects. I was extremely torn when I had to choose between science or the arts at the age of 16 and I attempted even to carry on some arts subjects with considerable difficulty.

I myself hope that the current enquiry by Ron Dearing investigating what is going on at the 16- to 18-year-old level looks very closely at the possibility of broadening A-level to five subjects with some sort of core competence. I would not allow pupils to choose randomly any one of 25 different subjects, but I would keep a core two or three subjects and then allow choices of the others. The Engineering Council interestingly points out that they believe that if one dropped General Studies as not being necessary in this broadened array of subjects and decreased the content of the A-levels by only 20% for each of the subjects it would be possible to accommodate five A-levels. I think that probably needs closer looking at, but it is an interesting point. There would of course be consequent knock-on effects of the reduced syllabi in the universities, but I am pretty sure that if it were a clearly defined core competence in the important subjects, the maths and science that we need, then it would actually make matters easier for us.

Conclusion

So to conclude, I think I would focus very much on teaching in mathematics.

We have to give children the confidence to go on in the sciences because they all say it is 'hard' and what they mean by hard is that it is mathematical. We also have to pay serious attention to the perceived reduction in mathematical competence of those who are entering university. What happens between 16 and 18 in the schools seems to me also to need attention because the low take-up of science and maths has been going on for a very long time. Finally, somebody, somewhere, should look at paying scientists, engineers, and those teaching them in the schools the appropriate amount of money to encourage the very best into those areas.

Mr Martin Tims*

Introduction

I am a chemical engineer. I have been with Esso for about 25 years. For about the last nine years I have been Manager of the Education Support Programmes that we run. I say it is the best job in the company; much to my amazement people welcome me with open arms. It might have something to do with the fact that Esso invests about £1 million a year into the Education scene in a whole range of areas.

Why is industry interested and involved?

What I would like to do is to try to put over something of industry's view of how, where and why industry can, and does, get involved. But maybe the best place to start is to ask 'Why *should* industry get involved?' and I think I would start by saying that most companies have got very legitimate interests in education. Most of our employees are parents, many of them are spouses of teachers and I am delighted to say that we have about 100 members of staff who are governors. Also, we take much of education's output as recruits. But that said, recruitment as a driver for the educational support work has to be treated with care because it can lead to a very short-term view of things.

I would certainly agree with what Professor Higgins said, in that we do need an informed public, as we need an informed climate of consent for our operations and we need to be seen as concerned corporate citizens. We do contribute a lot into the education world, not just Esso but other companies as well. An interesting statistic that a colleague of mine dug out was the amount of money that Esso collects and pays as tax. Recognizing that the vast majority of the petrol price that you see at the pump is in fact excise duty, VAT and Petroleum tax, we actually contribute about 10% of the total UK education spend through the amount of taxes that we collect. So I think we have got a legitimate interest!

The key aspect of long-term relationships between industry and education is not to use what I call the begging bowl or the deficit model of education, but lies in asking 'What can industry gain from working with education? What sort of human resource benefits are there, in terms of management development? What sort of PR benefits are there?' The press mentions the use of the logo, and, I say the currency I can deal in when in the boardroom arguing for education support budgets. Last, but by no means least, small companies can get a lot of useful help from education, particularly in terms of schools as centres of excellence of IT or of languages, and the schools also have facilities that maybe the companies can use.

I must put a couple of health warnings in here! Industry is not homogeneous, and I cannot speak for the whole of industry. We have a range of sizes, a range of locations and even within my own companies I find opinions differ quite markedly. Also, Industry is changing, and you all know about the downsizing, the de-layering, the flexible working, and therefore this is leading to a lot of students having to look at multiple careers.

Some companies take a lead in working with Education, and I am delighted to be associated with one of those. We have been supporting education for many years and we try to help the recent converts to the game - perhaps one of the most successful examples of that was a programme that we did jointly with (what was then) the DFE and the Employment Department, 'Making Education our Business'. This booklet, developed by the University of Warwick, shows other companies how best to work with education.

We are not the educational experts. We can certainly say what we want; we can be an interested stakeholder, but we do not know all the answers, and I feel that industry, while it can help at the periphery, should not, and cannot, replace government funding, cannot replace the teachers, cannot replace the schools.

All that is by way of an introduction. What I want to talk a little about is what Esso wants from its recruits and then look at when, how and where companies can and do support maths and science education. I shall look at four key areas, which I am calling the formal curriculum, the whole curriculum, a bit on teachers and a bit on public understanding.

What does industry want/need?

I want to talk mainly about schools, particularly primary, because I think that is the area of most need. I will concentrate mainly on England and I think the underlying theme is that we do need to keep the students switched on to science and mathematics. If you like, it is the opposite of the Jesuits; once we lose a child to science and mathematics we have a major job to try to convert them back again, and therefore a lot of what I will be talking about is saying how can we keep them switched on?

Esso recruits about 40 or 50, mainly graduates, each year, a relatively small number, but put that into the context of when I joined Esso 25 years ago when we were a 16,000 workforce. We are now down to about 3,000 and we are going down by the day. So we are less than a fifth of the workforce that we were. Of those 40 or 50, probably 70% are scientists and engineers and I am delighted to say that about 40% are female scientists and engineers. We put a lot of time and effort into attracting female graduates to us.

So, very quickly, what does Esso want? I mentioned that industry is changing, but, that said, what do we look at when we are looking for recruits? The key subject areas in terms of knowledge from our point of view are obviously Science, Technology, English and Maths and a very good awareness of environmental aspects. But we need to recognize, as a colleague of mine says very frequently, that the half-life of knowledge is falling like a stone. Probably, for a student leaving university, within two or three years half of their knowledge is redundant, it has been overtaken or they have moved into a different work area. So, as important as the knowledge is the ability and the

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> The danger is that too restrictive a choice of A-levels can actually shut out career choices, particularly engineering career choices

discipline and the desire to learn to update one's knowledge, to adapt and to go in for life-long learning. We want to see enthusiasm, a positive attitude to industry and the potential to reach the top.

We look for the core skills: literacy, oral fluency and numeracy. We are a very IT-literate company, we do want to see creativity and problem-solving and we do need to recognize that most of the work that is done in industry is in fact working in informal teams, so interpersonal skills are also important. Now we could argue until the cows come home about definitions of core skills and the one omission that you will see in my list is modern foreign languages. That is because Exxon worldwide uses English. I could pick up the phone or use the electronic mail anywhere in the world and speak English.

The formal curriculum

So we see the need for basic knowledge for all students. What a colleague of mine says we need is an understanding and an 'unconscious competence', if you like. This should include, obviously, reading, writing, oral fluency, mathematics (including the times table). I do find it a shame that we are disenfranchising a lot of students by not giving them the basic mathematical skills of addition, subtraction, multiplication and division. It frightens me to go into a shop and buy ten items at 9 pence each and the person has to go the till, work it out and if you give them a pound and the till comes back saying the change is £10, they will give you £10. To me that is absolutely stupid. I will not go into how we should be teaching these maths skills as that is the job of the experts, but I do feel we need this unconscious competence in mathematics, and I would then underpin that with a scientific and economic literacy for all students and I would add into there some environmental awareness as well.

We do welcome the National Curriculum, particularly the science, technology, maths and English for all, but I think the jury is out on balanced science, as there are pros and cons to balanced science versus separate subjects. I think the five-year moratorium has been one of the best things to have happened in education recently, for two reasons: I get the distinct impression from talking to a lot of teachers that they are much more comfortable now that they can actually plan, equip themselves and deliver the National Curriculum, particularly maths and science, knowing it is fixed until the end of the century. But it has also given a breathing space to the educational resource providers, the publishers and the organizations that we sponsor, because they can actually get on knowing that they do not have to revise resources every five minutes.

One of the main areas where industry can help is with what I call 'contexts' and hands-on experience, in science and maths, because these do add excitement and relevance. I was delighted, Minister, to hear you mention the Supported Learning in Physics programme that we and Ford and the Institute of Electricals are supporting, with the Open University. Other examples include Salters Chemistry, the Mathematics Enhancement Programmes that Professor David Burghess is doing down at Exeter – bringing in the context of loading our tankers, i.e. why it is that you cannot just load petrol into the tanker without looking at the maths involved (because if you did it would probably tip up backwards), and then showing the students what the relevance of that is to maths, how you should calculate the volume of each compartment and so forth – and projects like SATIS, the Science and Technology in Society programme from the ASE. There is also a lot of work going on giving students hands-on experience, such as the Launch Pad, the Exploratory, Techniques, etc., taking students to give them hands-on experience. I do not know whether anybody has recently been to the Launch Pad at the Science Museum, but do please go and just see the excitement of the children using some of the scientific equipment. We are also working to help give this experience in schools, with organizations like the Institution of Chemical Engineers and their 'Fascinating Science' boxes, which are boxes of goodies to take into the school to give hands-on experience there.

Turning now to the more vocational side, we do welcome particularly the core skills emphasis and the competency basis for GNVQs. I think, however, the two aspects that I am slightly worried about are: the question of assessment, where I do think we need a bit more rigour and a bit more objectivity; and I do think we need a moratorium on what I call the sniping at GNVQs, with too many people trying to 'dig up the GNVQ plant to look at its roots to see if it is still alive'. It is a pilot, so let the pilot run and then evaluate it rather than continually try to change it.

On A-levels and feeding into Sir Ron Dearing's review of post-16 qualification, the recent CBI survey showed that in general most of industry does want to see some changes here. I think from our point of view, the danger is that too restrictive a choice of A-levels can actually shut out career choices, particularly engineering career choices if students drop maths and/or some sciences. I would personally like to see a science and a core skill strand in all A-levels and GNVQs, so that children cannot drop science at 16. There is also the problem of the maths entry to higher education, as Professor Higgins has mentioned. I have two reasonably simplistic answers to that. One is 'Why don't the maths exam boards and the engineering professors talk together and decide what is the required core and then get on and make sure that the core is agreed by all', and the other is 'Why do we not look at a combined physics and applied mathematics A-level that would be a precursor to going on and reading engineering?' Again, we need to get the engineering professions, through the Engineering Council maybe, the exam boards and the university professors to sort out what, exactly, that should need.

Beyond the National Curriculum

If we then look at what I call the whole curriculum, Sir Ron Dearing's previous review has allowed schools to look beyond the National Curriculum. We are very interested in supporting the cross-curricula themes, particularly where they have an impact on science and maths. I do think though that the stop/go approach in recent years to cross-curricula themes has damaged a lot of the good work that was going on, and a recent NFER Survey has shown that particularly economic and industrial understanding is under threat in schools as the TVEI funding ceases.

We would like to see more development of core skills, for all, and we must start in the primary area. We must extend the core skills into A-levels and there are many projects that we support and others from industry support that help here: things like CREST as the Minister mentioned, Young Enterprise, the Comino GRASP (Getting Results And Solving Problems) project, and egg race-type activities. All of these do in fact help in terms of developing these team-working and creative and problem-solving areas.

I think one of the main problems that we have at present is careers education and guidance. I think we start it too late, and feel that there is currently too much emphasis on the quantity and not enough on the quality. The Competitiveness White

Paper was a good start, and I was delighted to see the SCAA 'Looking Forward' report mentioning careers education and guidance in primary. But if we do not actually show the students what the relevance is in taking science and mathematics, they are not even going to consider careers using them. We all need to encourage positive attitudes to industry, to science, to maths and to careers in these areas, and we in industry must help the teachers. If not, the danger is that students will see industry in a very poor light. We and many others support what we call taster courses and activities which actually show students which careers use their science and mathematics. But all of this is going to be so much more difficult if we do not recognize that the key to the delivery of all this is, in fact, the teachers.

What worries us is that many, particularly primary, teachers still go from school to college, and back to school to teach. Or, as somebody said to me, even worse - they go into industry, they have a bad experience in industry and then go into teaching with an anti-industry attitude.

I meet a lot of teachers, and many tell me that they do not feel adequately prepared or trained, not having the significant subject knowledge, to teach properly science and maths. I was on the Council for Accreditation of Teacher Education (CATE) and thought we had actually managed to match the requirement for a mathematics entry qualification with a science entry qualification, but when I was talking to Anthea Millet the other day, it seems as though progress on that has gone a little backwards since CATE folded. So, initial teacher training is a key area. We must make sure that all newly-qualified teachers have proper knowledge, skills and attitudes towards science and maths, and also I would put in there some training in terms of careers education and guidance.

On in-service training, we need a lot more of the work that much of industry is doing in terms of helping to increase teachers' subject knowledge, particularly at Key Stage Two, Science and Maths. Things like the 'Making Sense of Science' videos, the Regional Technology Centres and the packs that have been produced with industry support are all good. We also need to look at updating the teachers for the changing scientific world, and to recognize that subject knowledge is a prerequisite, but what a colleague at Oxford University calls 'teaching knowledge' (i.e. how to put over that subject knowledge) is equally important.

Public understanding

I do feel that much of what I have spoken about is not really going to be that successful, unless the public and parents have an awareness and positive attitude towards science and maths. We fully support the work of COPUS (and the British Association Media Fellowships - which get academics to go into the media). We support the Foundation for Science and Technology and we applaud the work that the Research Councils are doing on public understanding. I also do see Action for Engineering as a major opportunity, but the danger I see there is that it may turn into a very *top-down* co-ordinating type of activity, rather than a *bottom-up* co-operative activity.

Conclusion

To sum up: if I have to pick out, from that great long shopping list, some key points, I do think that:

(a) we need the basic science and mathematics knowledge, skills and attitudes for all students. We cannot afford to have them dropping out or being turned off. Industry can and does help by offering the context in which students can experience excitement and relevance; and

(b) we do need now all newly-qualified teachers to have some sort of science, as well as the maths, qualification, and I would put that as an entry qualification for all teachers; finally,

(c) we do need a better understanding of science and maths for the public in general such that informed decisions can be made.

▲ *Guests at the lecture and dinner discussion on the place of Maths and Science. From left: Professor Rosalind Driver, Professor of Science Education, King's College; Mrs S. Sadeque, Educational Consultant; and Mrs Jean Beck, Director, NCET*

PUBLIC AWARENESS OF SCIENCE AND TECHNOLOGY

A contribution from *Dr R.G. Evans*, Principal, Stockport College of Further & Higher Education.

Dr R.G. Evans

Summary: How can a greater public awareness of science be achieved? The mass media had an important role to play but too often conveyed an erroneous impression due in part to lexical complexities. There was need to reconsider exactly what we meant by the word *understanding*.

Introduction

Following a recent lecture at the ASE's Annual Meeting, on the public understanding of science, I reflected on some of the issues raised and would like to share some of my thoughts in this article. I accept that a lot of the issues have already been aired before, but hope the article will trigger further discussion and debate on this important topic.

The need to raise awareness and greater understanding of science is now irrefutable, as we all live in an increasingly scientific and technological world. The advent of the information revolution, driven by information technology, further requires members of society to be better informed of science and technological advance. Schools, colleges and universities obviously have a major role to play in this endeavour, but with the need now for lifelong learning, other agencies must be involved, and that most certainly includes the mass media.

The communicators

So, who should be the main agents that bring about the greater understanding of science? The view held by some is that it is the front-line scientists and researchers who should be the agents. They should be trained to become effective communicators and monies should be used from the research allocations to facilitate this activity. I fear such arguments are flawed, as the vast majority of researchers are inherently incapable of effectively communicating their subject to the public at large, let alone explaining all the associated elements of the various topics. Formal courses, surely, could not immediately create a legion of gifted communicators. Researchers, after all, want to do research and not be required to explain to the public at large their discoveries, ideas and theories. Many, in fact, feel that the very act of attempting to do this debases and dilutes the purity of their subject. It is, after all, one of the elements of the Guild of Science that it is often perceived as a closed and somewhat inward-looking academic community, and I would argue that in many cases this should be respected. Effective communicators are a rare breed who have to possess a very special range of talents, especially in such a complex and multidimensional topic as raising public understanding of science and technology.

One important aspect is that other dimensions need to be explored, attempting to get the public to understand science and technological developments and advances and their possible consequences for the world. Joseph Needham used the wonderful expression 'an ecumenical universe of science and technology, valid for every man and woman on the face of the earth'. I interpret this to mean that science and technology cannot be divorced from other subjects. Its roots are multicultural and it is very much a multidisciplinary subject and needs to play its part alongside religion, philosophy, history, politics and artistic experience. I would argue that for the public to gain a greater insight into the understanding of science, these elements need also to be articulated to them in an understandable and comprehensible way.

This is not to say that there have not been some very gifted communicators and popularizers of science. Names that immediately spring to mind are Richard Feynman, Murray Gell-Mann, Russell Stannard, Frank Close and the late Jacob Bronowski, but there are, sadly, very few, and I feel this kind of steerage and proposal would not bring about the hoped-for changes. Very often, non-scientists can be the best communicators of science and its associated dimensions.

Role of the mass media

This brings us, then, to the role of the mass media. The mass media have a responsibility to raise awareness and to develop critical understanding of science and technology within society. Too often they use hype and whizzbang approaches to impress and further engender the sense in people that science is mysterious, weird and incomprehensible. They too often fail to inform and encourage insight by the readers/viewers. Popularizers must be explainers and must stimulate and sustain scientific awareness and relate it to the products and services of their daily lives. Many people argue that journals and the tabloid press have a responsibility to raise awareness of science and technology. As indicated above, practising scientists and researchers are often reluctant to communicate about their subject, often feeling it simplifies and belittles the subject, and many journalists often find it difficult to obtain information from the scientists and researchers.

One of the problems that technical and popular science journals have is the issue of lexical complexity. Science and technology, by definition, can be dominated by specialized jargon and abstractions. Hayes attempted to quantify lexical complexity by carrying out a very careful analysis of the proportions of jargon and uncommon words within various publications. He assigned an arbitrary scale, for example, to English Newspapers, 0 being the average. Any value under ten is considered to be a typical day's read and is comprehensible by the vast majority of the population. He computed a range of values for a typical day (3 June 1992) and these were as follows:

The Sun	-11.0
Daily Express	-2.7
The Economist	0
The Times	+3.4
The Guardian	+5.5
The Financial Times	+9.6

Hayes extended his analysis to scientific journals: *Nature* attracted a lexical complexity of +40 and *Scientific American*, often perceived as effective reading material for the lay person, had a value approaching +15. Other more specialized journals had scores in excess of +50. Obviously, these high scores are understandable, but ensure that only specialists in that particular area of study can hope to comprehend the content of these publications. The key issue for the public understanding of science is how journals such as *New Scientist, Science and Public Affairs*, and *Scientific American* can communicate the ideas to the lay reader. Not easy, because clearly science has to have its own scientific language, low on redundancy, and therefore highly specialized terms are used, and clearly the associated mathematics adds to the difficulty. This challenging area, I feel, is very fascinating to those who are desperate to improve the awareness and understanding of science in the general community and merits further research.

Measuring performance improvement

Another factor which intrigues me is that some seem to think that one can gauge public understanding of science and its possible improvement if some of the above proposals are implemented. I must admit, I have difficulties with trying to understand how one could measure performance improvement, although I do appreciate that it is a classic example of the free market. After all, there seems to be a performance indicator for everything these days.

But how do we gauge public understanding of science and its improvement over a period of time? Surely not by using simple questionnaires or surveys which reduce it to a sort of *Ask the Family* or *The Brain of Britain* approach, which require just simple recall about how many planets there are and who discovered the laws of gravitation. I suppose in some ways this brings us full circle, and possibly there needs to be a reconsideration of what we mean by the word *understanding* in this context.

How do we gauge public understanding of science and its improvement over a period of time? Surely not by using simple questionnaires or surveys which reduce it to a sort of *Ask the Family* or *The Brain of Britain* approach, which require just simple recall about how many planets there are and who discovered the laws of gravitation

Whatever happens, it clearly is important that we continue to seek ways, through formal education and training and lifelong learning, to bring about a greater understanding of science by the public and it is essential that we ourselves know what the word *understanding* means.

LETTER *to the Editor*

Investing in small firms' growth

Mr David A. Ball writes:

I recently attended a Foundation for Science and Technology evening entitled *Investing in Growth.* The speakers made some compelling points and the discussions brought out some telling replies. Despite the robust discussion, someone commented that we have come a long way; ten years ago getting the investment community together to discuss these issues in the same room would not have been possible. Many important issues were raised in terms of the help available and the pitfalls faced in starting a new enterprise in the high-tech industry.

It was plain both from the presentations and discussions that there is inevitably a huge skills, knowledge and experience gap between the entrepreneurs with the idea and those who are asked to assess the risks and support the idea with investment. Another major issue was the need for help and counselling in the broader skills in running a successful enterprise for the long term; these inevitably become necessary as a venture develops but which the entrepreneur team may lack.

Similarly, entrepreneurs often are ignorant of the requirements and concerns of an investment source.

These two groups almost literally speak different languages. I put forward the idea of a 'translator', a person that has a broad understanding of the technical, market and investor issues, to bridge the gap. This would be an extension of 'angel schemes' and I suggested large companies in this field might willingly offer services of an advisory kind as an extension of the current DTI initiatives to help SMEs (Small Medium Enterprises). This idea, if successful, would avoid some of the more serious misunderstandings that so often occur between these groups, which is disastrous in the early crucial stages of a new business, and also help bridge the 'experience gap' in the later stages of a project, particularly at the inevitably crucial part of deciding whether to inject more investment or pull the plug.

In my company, Nortel, we already have schemes to expose SMEs to our corporate culture, particularly in assessing the viability of projects from both a product and a market perspective, dealing with many of the issues faced by a new business, i.e. looking at the potential return on equity, the timescales to a positive cashflow and the resources required. We also are often asked by our principal customers to advise and provide practical help with a small supplier to them who has a good product and yet has got into difficulty (usually cash flow, sometimes expertise or technology) and we often oblige. This help has on occasion extended to starting a small equity stake ourselves, putting some expertise on the Board yet leaving the small supplier with a majority and enough equity to make it worthwhile to soldier on.

I believe this is an enlightened approach to helping both the SME and often ourselves and, of course, investors always feel more comfortable with a major company backing some of the risk.

Time precluded a discussion of how such a mechanism might work in practice, but the suggestion may merit further consideration.

David A. Ball
President and Chief Executive Officer
Nortel Ltd

Dr Michael Elves writes on the missing technicians: page 21

SCIENTISTS AND PUBLIC OPINION

On 13 December 1995 the Foundation held a lecture and dinner discussion at the Royal Society under the title; 'Do Government and Industries' Scientists listen to Public Opinion?'. The Lord Butterworth, CBE, DL, was in the chair and the evening was sponsored by Copus and Zeneca plc. The speakers were *Professor Robert M. Worcester*, Chairman, MORI; *Sir John Egan*, Chief Executive, BAA plc, and *Professor Lewis Wolpert, CBE, FRS*, Department of Anatomy and Developmental Biology, University College London Medical School and Chairman of the Committee on the Public Understanding of Science.

Professor Lewis Wolpert CBE, FRS*

Summary: **Professor Worcester said the definition and application of 'public opinion' had exercised the minds of many thinkers in the past. He gave his own interpretation and went on to discuss the role of polls giving examples of the results of MORI investigations relating to technology. Professor Wolpert concluded that scientists had to work much harder at understanding the public and discover ways in which they in turn could communicate with those who undertook decisions on their behalf. Sir John Egan emphasised the need for scientists and engineers on large projects to be able to gather precise information as to what the customer wanted.**

Introduction

Public understanding of science is very fashionable at the moment. It is doing very well and is even part of the mission statement of the Research Councils. I think there has also been a change in attitude. Most members of COPUS will agree now that it is not just the question of the public understanding of science, but of scientists understanding the public. The old idea that if only we, scientists and engineers, were understood, everything would be all right, that all our problems are due to our being a poorly understood group (we probably are), is no longer satisfactory. It is a question of power and trust. In a way I am a little unhappy with the title of this meeting. The irony of life is that scientists and engineers have, in fact, extremely little power. Historically, although scientists and engineers built the atomic bomb, the decision to build the bomb was taken by the politicians. My overwhelming impression is that scientists and engineers have extremely little power in making any of the important decisions and the real question is whether the power makers or the power-deciders, or the people who hold power, really are listening to both scientists and the public. So I think the title of this meeting is not quite right.

I emphasise this point in relation to engineers, I am horrified to hear what is happening to the construction industry because I was a civil engineer many, many years ago. I always challenge an audience, not a lay audience, to name one modern engineer. I say 'Just give me a name, a figure in engineering', and they say 'Frank Whittle', and I say 'Somebody a little bit more recent than that'. They can't do it. The engineers have done very, very badly with their public image. Having said that, I want to begin where I really want to end. Everything I would like to say is in this statement from Thomas Jefferson, because it is the essence of the public understanding of science and scientists understanding the public.

> I know of no safe depository of the ultimate powers of the society but the people themselves. And if we think they are not enlightened enough to exercise that control with a wholesome discretion the remedy is not to take it from them, but to inform that discretion.

This should be embedded in the hearts of all those in power in relation to science and engineering.

How well do we perform?

COPUS and many other people are now involved in the public understanding of science, but how well do we actually do? What is it we actually want the public to understand and how do the public get access to the people who have power? It is extremely difficult. I ask myself repeatedly, what is it I want the public to know about science? As Chairman of the Committee on Public Understanding I should have a ready answer to that. I regret I don't. Do I really want the public to know about DNA? Do I really want them to know about Newton's Laws of motion? It would be nice but not essential. I have come to the conclusion that what is essential is that anyone interested in science should have access to science and to the scientific process and have *access* to scientists and engineers. One of the main aims of COPUS is to persuade scientists and engineers to make greater contact with the public. Such access could even provide the media with new perceptions. For example, an experienced interviewer asked me on *The World This Weekend* in relation to BSE, 'Doesn't it worry you that scientists are disagreeing, is this not lowering the whole public perception of scientists that you all disagree?' I said 'No, that is what science is about, this is the healthiest thing that has happened for ages.' But the very fact that somebody as intelligent as this interviewer should be asking that question is very disconcerting. It means the whole public perception of science, even amongst the media concerned with current affairs, is very confused.

One has to recognize that a real problem with science and the public is that science is a bit weird; it involves an unnatural mode of thought since the world is not built on a common sense basis. My claim, which you may not like, is that if an idea fits with common sense, then scientifically it is bound to be false. I know of virtually no counter-examples. I used to say that Ohm's Law was a counter-example, but people who taught it said 'Forget it, people have all sorts of difficulties.' Particularly with resistances in series/parallel in an electrical circuit. I think it is also very important for the public to understand that there is a difference between applying science and scientific knowledge itself. There is really a difference in knowing how things work, in knowing how to build an atom bomb or a nuclear power station, and actually building one. The power base and the social relationships are very different. This is very relevant

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to genetic engineering, for example, where there are numerous anxieties. These anxieties are blown up, I believe, out of all proportion. I am a cyclist, and I claim potholes in London are a much greater social danger than genetic engineering because people actually get damaged. Science is not the same as technology and it is essential to keep the distinction clear.

Trust

One of the big issues we have to face is the question of trust. We need a means for finding out what the public wants to know. One has to be a little cautious about surveys since I am always reminded that surveys show that in this country most people would like to restore hanging and yet Parliament, in its remarkable wisdom in this particular case, has actually decided not to. In other words, I am not persuaded the public actually know what they want, or that they should get what they want. When you tell me that they do not want a 200-foot-high ceiling, I don't think they have ever thought about it. Perhaps when they see it, they quite like it. Maybe we are prepared to pay for pleasure. St Paul's Cathedral, did it really need to be that high? If you went to an early cathedral builder they may have said the same thing, but what a pity if they had listened in relation to science. Access is the key.

Our real problem is how to ensure that the public feel more empowered in relation to decision-making. A good example of where everything, I think, was done the right way was the legislation on Human Embryology and Fertilisation. It deals with what scientists were allowed to do with human embryos. There was very wide public debate in the press, meetings, on television, everywhere. Now I thought that was terrific. It went to Parliament, there was a decision - whether you like the decision or not is neither here nor there - that was democratically taken after a great deal of discussion. That is what democracy is about. It is the same with abortion, euthanasia and like issues. What worries me is when politicians take decisions in relation to science without consultation. As I understand it, Jill Knight, in relation to the Criminal Justice Bill, just added a clause without any consultation, without any public debate, saying that one could not use the eggs from deceased people, or from aborted foetuses. Now that may be right, but what I object to extremely strongly is that the public were never consulted. My whole point is that you will never win the trust of the public unless they somehow feel they are empowered in some way and involved.

It is enormously to the credit of the Biological and Biotechnology Research Council that they have experimented with the Danish technique of having what are known as Consensus Conferences. They took a small group of people from the public who know nothing about biotechnology. They gave them all the expertise that they wanted, as well as lectures in relation to plant biotechnology. Then they discussed it and gave their views. On the whole they ended up with what seemed to me a pretty reasonable set of decisions.

I think that anxiety about trusting the public, from the point of view of scientists and engineers, needs to be discouraged. We feel that we are holding what I would certainly regard as privileged knowledge, because it is jolly hard to acquire and it is difficult. Nevertheless I think the evidence is that if you actually give people enough time and give them the information, they can come to pretty reasonable decisions. We have got to find a variety of ways to achieve this. I think consensus conferences is one way, public debates are another. Education of the media, I think, would be an enormous help so that we do not just have journalists giving their views, but that somehow they reflect more the public view. You might say that they do that anyhow because they are trying to sell newspapers and they have a pretty good nose for what the public actually wants to hear, but I think that is quite a tricky issue.

I am afraid I really don't have solutions, other than to say that scientists have to work much harder at understanding the public and that we have got to try to find some better way for the public to be able to express themselves, not so much to scientists and engineers, but to those people who are actually involved in taking the decisions that really affect our lives.

Sir John Egan*

Introduction

As well as questioning whether scientists and engineers listen, I'd like to spend some time wondering whether they have the capability of delivering. It is all very well to listen but are we gathering information in a disciplined, organized way that can be used? Do scientists and engineers have the project management capability actually to deliver what is required by the customer?

Let us just look at a very big project to clarify the point - say, the new British Library. Here it is quite clear what the public wants - we want to store lots of books in a tidy way that keeps them dry and has some delivery mechanism. But have we had the project delivered on time and have we had it delivered at a cost that we are capable of paying?

Project control

The control of large projects is one of the reasons so much of British industry has taken an early bath. The post-1960s British-owned car industry, for example, not only had a huge record of bad industrial relations, it also had an almost complete track record of replacing good cars with bad ones, simply because in the 1960s and '70s the industry lacked the capability of developing a new car which was better than its predecessor. The 1100 Austin Morris was replaced by the Allegro. Anybody of my age would realize what a fine car the 1100 was and what a bad one the Allegro was. Yet the Japanese seemed to be capable of creating high-quality cars where each one was better than its predecessor.

What were the differences? Essentially, the British manufacturer had no clear way of determining the marketing requirement. Generally speaking, they had an engineering-driven approach to creating a new model. A concept car was looked at early on by a board of directors (incidentally, the more important people are, the less useful they are in controlling large projects because their egos are usually far more important than the delivery of the project). Then, following the acceptance of this early prototype, the business end of the project went off in three directions.

One direction was market research-based, where the car was `clinic-ed' with lots of potential buyers going to look at it. The second route set off into the commercial jungle of the component industry looking for people to supply the various bits and pieces. This meant negotiating with suppliers and every component which differed from the original concept, of course, would require other design changes to accommodate it. Thirdly, another group, a completely different set of people, planned the manufacturing process. When all this was added together it was a very complicated and difficult set of processes. The car industry invested in huge amounts of 'critical path' planning in an attempt to control chaos. Usually a very bad product was delivered that could not be manufactured very easily, introducing a

* *Chief Executive, BAA plc*

great deal of bad morale on the shop floor and making industrial relations even worse.

How did the Japanese manage this same difficult process? Well, the first thing they did was to find out what customers actually wanted in a highly disciplined, market research environment. The market research department is an integral part of engineering in a Japanese car company. They want to create the new model the market place wants, not to shift the metal the company has actually made. This is an entirely different approach, putting market research at the beginning of the project. And so the Japanese divided this very complex project into a series of processes. (Incidentally we are talking about 6,000-7,000 'man' years of engineers' effort here, all with IQs of over 130 and the bigger the IQs the more difficult it is to impose group discipline.)

First market research. Then design. All the components were designed at the same time. The suppliers, therefore, had to be put in place at the time the design started. The manufacturing processes were also developed at the same time. Then, perhaps 1,000 prototypes were made to test the manufacturing methodologies. The car, easy to manufacture and capable of satisfying customers, was delivered on time and working on time.

Defining the public requirement

So the problem for scientists and engineers is not just knowing what customers want but being able to define that in a disciplined way and create a process of delivery which produces what is wanted. Let us look at some projects which have failed. Taurus, for example, the huge settlement project on the London Stock Exchange. Something like £500 million was invested in this thing with absolutely no output from it whatsoever, mainly because the people designing the process had not agreed on their objectives in advance. Or the Nimrod Aviation Radar System. Again, huge investment, no output.

There are, of course, some industries which are capable of delivering what the customer wants and typically in the UK these seem to be companies with relatively straightforward customer requirements. The oil companies, for example, are certainly world-class. Our drug companies – again relatively straightforward. The customer has a sore stomach – the companies aim to supply the remedy. I appreciate we have to find out what makes the stomach sore in the first place but the delivery of drugs to correct the problem does not require a huge amount of complicated market research input. In this country we are capable of doing very difficult and huge projects but only in a small number of world-class industries. If we are going to be capable of delivering what customers want we have to design a complete system as the Japanese car industry illustration shows.

Let me now turn to delivering world-class projects in the construction industry. It might be easier to start with a description of how not to deliver a world-class project. Let us imagine we are in Sydney and we want to build a theatre for opera. We start by finding a world-famous, brilliant, architect. He designs something extremely beautiful, something that will be talked of long after he is gone. Now we ask people to tender for this building. All construction companies know, of course, that architects design things that cannot be made, but on the other hand they know they have to win tenders, so they come in with a very low cost knowing that they will make their money out of changes to the design. Most British construction companies create their claims department before the project has even started in much the same way that the UK car industry made its profits out of selling spare parts to motorists rather than out of the original car.

Back to our opera house. The claims department is already up and running and, of course, the construction company is trying to help the architect design something that can be built. By this time the construction company will usually have installed a hut on the site, put up a big wire fence and will have started building. It is very important to get building. The client likes to see something going on. Of course, this early building work does not usually fit with the building that can actually be made, so quite a lot of bodging goes on trying to make things fit and you design as you go along. At some later stage, when the building is half-way up, middle management suddenly realizes to its horror that the whole project looks as if it won't work so they try to bring in a new wave of changes to pull things round. By now a date has been fixed for the Queen to open the building and you know how difficult it is to get a date in Her Majesty's diary. So suddenly in a huge rush something like 65% of the cost of the building is added in the final year or two of the project's life and you end up with something possibly costing five or even ten times the original estimate. And to cap it all, the Sydney Opera House cannot actually take big operas because the stage is too small. As George Christie, whose family has designed two opera houses, knows, you have to design the most important bit first, which is the stage, and then construct the rest of the building around it.

> We also try to take the project out of the hands of the board of directors, who are usually the most dangerous people involved in a project

Finally, let me leave you with an impression of how successful processes can work and how my own company, BAA, is trying to create buildings which people will like at world cost levels. Currently the British construction industry's cost levels are about twice the world best.

We start off with a huge amount of customer data from all our existing buildings to find out what customers want and then we build accordingly. We have discovered, for example, that no customer has ever asked for a 200ft ceiling in a terminal. I was horrified when I went to Frankfurt to see such a thing. We direct our money and effort specifically to what the customer actually wants.

We also try to take the project out of the hands of the board of directors, who are usually the most dangerous people involved in a project. We create a local project board of wise men who actually have to live with the results on a day-to-day basis and who are challenged to produce a better, more cost-effective building than before. We have discovered that a project board of experienced middle managers is probably our best bet for obtaining the high-quality, low-cost project we require. We have benchmarked world-best standards from all round the world and have a team of development directors to guide the project board in this area and also ensure that best practice is spread to our other projects.

Computer modelling techniques provide an enhanced insight into the final look of a project and all the various customers at the airport have to sign off a project at the design stage to indicate that they agree it.

In an effort to bring down our building costs to world levels we have established a list of standardized components. We discovered that the customer does not particularly want a newly-designed lavatory every time he uses one. The same lavatory seems to work for all human beings so we have standardized our lavatories just as we have standardized our carpets, light fittings, air conditioning and so on. This means we can always predict how the building is going to be assembled and concentrate on improving the process. We also have framework agreements with all the suppliers who are going to be putting the building together.

A team of actors coming together who have never worked with each other before seldom create effective processes. But if the same group of actors which built the last building come together again then you can expect improved productivity. By these means, we are hoping to build at world levels of cost and we have indeed made significant reductions.

We are on our way to what we hope will be a world level of cost, at which stage we'll have to take a deep breath and wonder where we will get our continuous improvement in the future.

Conclusion

I will finish by stressing what I believe is necessary if the scientists and engineers are going to deliver what the customer wants: they need a very disciplined way of gathering precise customer information so that it can be applied to the project that follows. And they have to make sure they have a project management system that can deliver what was intended.

We regret that, due to lack of space, we were unable to include the paper by Professor Robert M. Worcester. This will be given in the next issue of the Journal.

MORE NEWS *in pictures*

Lecture ends with a sporting gesture

◄ *Members and guests leaving after the Foundation's lecture and dinner discussion A forward look at science, technology and engineering were still able to watch England in World Cup action, thanks to their host, the Royal Society. The Society had thoughtfully provided a television in the entrance hall so that guests were able to see the final penalty shoot-out between England and Germany.*

Looking into the future

► *Professor Sir Brian Follett, FRS, Vice-Chancellor of the University of Warwick, addressing guests at the Foundation's lecture and dinner discussion Younger scientists and engineers. It's their future. The event, held at the Royal Society, was sponsored by Glaxo Wellcome plc, IBM United Kingdom Ltd and the Smallpeice Trust.*

LEARNED SOCIETIES' JOURNALS AND THE INTERNET

In February 1996 the Foundation for Science and Technology held a seminar jointly with the Association of Learned and Professional Society Publishers at the Royal Geographical Society.

Professor Bernard Donovan*

Summary: **After hearing some case studies of websites being successfully launched by learned societies, Professor Donovan described some of the challenges in publishing which learned societies will have to face in the coming years.**

Introduction

Much was heard much during the morning about the possibilities and practicalities of electronic information transfer. In order to broaden the horizons of those present, let us consider electronic information transfer from the point of view of learned and professional societies. Such societies exist to promote knowledge in a particular field, to encourage interest in it, and to set standards of practice. In short, they aim to advance the science of biochemistry, the practice of accountancy, the development of road transport, or whatever. Professional societies can act overtly, in establishing recognized standards of practice or by developing recognized qualifications with membership and fellowships, or they can act implicitly, by publishing only material of the highest quality. Material that is peer-reviewed and properly edited.

The Internet is splendid for publicising meetings, communicating with members, sending E-mail messages to particular groups of members and for the operation of bulletin boards. Capital outlay is relatively small and operation is cheap. For academics, of course, the Internet is free at the point of use, and that colours their outlook, while encouraging exploitation of the system. It is almost expected these days that societies and institutions have their own home pages, or a presence, on the Web. For clubs and associations and informal communication, the Web has much to offer, but when we come to more formal communication, like the publication of research papers, academic articles and so on, siren voices are heard: Publish on the Web, they proclaim, let the world see your findings quickly, but, in addition . . . give it to us free of charge. It would be folly to succumb to such blandishments, as will be shown.

Publishing and the Internet

Some points are worth making in connection with publishing through the Internet:

1. It is feasible to publish journals on the Internet, but if good illustrations are required, and high quality, the process is not cheap. In order to preserve the quality of output, it is still necessary to referee and edit manuscripts, to lay out the journal attractively and to carry out all of the customary steps, apart from the final printing stage. Cost savings are thus relatively small. Real figures are very difficult to come by, but the savings might amount to 30%, although the costs of preparation for loading onto and the management of a server must be added to the final bill.

2. It is not easy to derive revenue from electronic publications. Most publishers experimenting with this medium provide an electronic version in parallel with the printed version and are adding a mark-up of about 15-20%. But librarians are objecting to this extra charge, and the complaints seem set to grow. A few publishers are issuing purely electronic journals which are, as yet, free. However, this delightful situation for the reader cannot be sustained and charges are likely to be imposed next year.

3. The Association of Learned and Professional Society Publishers is involved in a project under the FIGIT programme which is exploring the ways in which small societies can get involved in electronic publishing. We have two guinea-pig member societies: the British Psychological Society and the Society for Endocrinology, and are working with the School of Electrical Engineering and Computer Science in Belfast.

The psychologists aim to produce an electronic version of a well-established printed journal, the British Journal of Social Psychology, three months in advance of printed copies. Further, provision is being made for an e-mail-type commentary to be attached to the electronic papers with the intention of embellishing the printed version with a digest of the reader's remarks.

The Society of Endocrinology has different aims, for while it also intends to mount its major journal, *The Journal of Endocrinology*, on a server and to make abstracts of accepted articles available to subscribers ahead of publication of the full paper, it also wants to provide electronically searchable text for readers, as well as other electronic services for members.

The project has been under way for some seven months and already a variety of practical problems need to be resolved. Therefore, what is the best way of controlling access to the server? Access needs to be controlled in order to provide for the generation of revenue necessary to cover publication costs. Should each society member or subscriber to the journals be issued with a password? Should the computer check the address of each caller against a subscription list before allowing access? How should the commentary mechanism be managed? Should correspondents be encouraged to write on-line, so easing identification and linking problems, or should an off-line correspondence facility be favoured? How should document delivery be managed? How do we arrange to collect money? Should we manage the process ourselves, or should we hand over control to an intermediary, while paying them for their services?

On another tack, we have to ask ourselves: How do we meet the needs of clients with different browsers or Web readers? In what form do we provide the information? As Acrobat (PDF) files, SGML, or bit-mapped images? These are different ways of putting information on screen and each has advantages of its own, as well as limitations. And, of course, how do we control or limit unauthorized copying?

* *Secretary-General, Association of Learned and Professional Society Publishers*

Most of the problems just mentioned will be resolved in the very near future although, paradoxically, the outcome could have serious consequences for the finances of learned societies. For, as electronic journal usage grows, it is likely that income from printed journals, which is already declining, will fall further. Cash flow will be greatly affected, for journal subscriptions are paid at the beginning of the year, and relate to material as yet unseen. By contrast, payment in the electronic world tends to be made on an item-by-item basis, with no payment for unread, or unwanted or irrelevant, information.

Electronic information is not the only factor affecting the viability of conventional printed journals. Other determinants include the shortfall in library income, leading to greater competition among journal publishers for the money available, and, in turn, to cancellations leading to shorter print runs, higher prices, and yet more cancellations. Then there is the networking of journal subscriptions by groups of libraries, so that one copy is shared by many users spread over several sites, and inevitably, inter-library photocopying, which is a natural consequence of networking. The current experimental use of site licences also merits attention, for these lead to the bulk purchase of batches of journals from large publishers and the discouragement of journal purchase from smaller competitors.

Despite the problems faced by printed journals, they are not likely to be replaced rapidly by electronic publications, whether on-line or in the form of CD-ROMS. Already, librarians are beginning to express some distaste for CD-ROMs on the basis that they are difficult to handle from the point of view of cataloguing and indexing, are easily damaged or stolen, that they need expensive equipment that can be used by only one person at a time, and that insufficient computers are available for the use of readers. Librarians also worry about the fact that the life-span of a CD-ROM disk is limited to 30, 50, or 100 years, depending upon the expert consulted and the quality of manufacture. Even if the disks last for a century, the equipment needed to read the disks of today in a hundred years will long be obsolete.

Some of the problems just outlined can be avoided by adopting purely electronic on-line services, or electronic document delivery. However, this mechanism is not welcomed by librarians because of budgeting uncertainties. Librarians dislike paying for information on an item-by-item or unplanned basis, and much prefer a licence or contract, such as the modish site licence. Even then, librarians worry about the task of taking out numerous site licences, one for each journal, or publisher.

Another aspect of electronic information supply that perplexes librarians, as well as many others, is that of archiving. No consensus has been reached about the best means of storing electronic information and preserving for posterity.

These features are important because academics and scientists are cautious about entrusting their life's work to a possibly ephemeral medium. Print-on-paper has served us well and will be supplanted only with caution.

It should now be evident why a variety of issues connected with electronic document delivery need to be addressed by learned and professional societies - particularly small ones with limited resources and reserves. For if a society relies upon its publications as a major source of income, then that spring can dry up, and viability be threatened.

Yet another reason why societies need to think carefully about these matters is that, in one respect, librarians might be regarded as going on the offensive. Because the ready availability of information electronically gives the impression that it should be cheap, regardless of its quality, the Library Association and Joint Consultative Committee representing Aslib, the IIS, SCONUL and the Society of Archivists is currently arguing that:

For works in digital format, without incurring a charge (apart from a possible subscription charge taken by the library) or seeking permission, individual members of the public should be able to: 'read, listen to, or view publicly available copyright material on site or remotely; browse publicly available copyright material' and to have copies made for them by a librarian under the principle of fair dealing. Additionally, this group of librarians is seeking the right to store copyright works as part of a document delivery service.

These demands require careful examination, for it seems that librarians want the right to access and copy digital material regardless of whether they have paid any subscription to the database or any fee for the information. They also want the right to allow remote readers (who may be calling from home, office or factory) to access publicly available material (which is not necessarily given away) without charge. The question of the definition of publicly available is not addressed and the impression is given that 'public domain' means commercially accessible. And if 'remote readers' are to be given access to information stores without charge, why should anyone take out a subscription to an electronic journal or database, when routing their request through a public library will get them what they want free of cost? What incentive remains for publishers to invest in refereeing and quality control systems when the final product has to be given away?

> Learned and professional societies' publications are stamped with authority and they serve as the gatekeepers of quality, and reliability. That is why librarians and others want to copy their publications - freely

The ideas just described have yet to be put into practice but policies need to be devised by learned societies to cope with, or oppose, them.

It is for such reasons that learned societies must think about the copyright aspects of their publications in the electronic world. Do they wish to give their authors the right to re-publish their papers on the Web? only after publication in print? or in pre-print form alone? How should they react to the views of the Library Association? Are they prepared to allow free and open access to their electronic publications by non-subscribers? What charging policies should be adopted for electronic material? Has the likely impact of such access upon their revenue been considered? Societies need to determine whether their publication income is likely to dwindle, or whether these new developments can be used to advantage. Is it better to licence others to digitize your material and publish it for you? Should alliances with others of like mind, to share experiences and benefits, be fostered?

The outlook for learned and professional societies is not necessarily doom-laden, for such societies, almost by definition, possess unrivalled concentrations of professional and academic expertise. Accordingly, their publications are stamped with authority and they serve as the gatekeepers of quality, and reliability. That is why librarians and others want to copy their publications - freely. Unfortunately, in order to provide their stamp of approval, through quality control, societies and institutions must provide expensive refereeing and editing services - and must recover costs by collecting revenue, in one way or another. This is why societies neglect these issues at their peril.

THE FUTURE OF MANUFACTURING

Under the intriguing title 'Let's hear it for manufacturing and construction', *Dr R.G. Evans*, Principal, Stockport College of Further & Higher Education, has submitted the following interesting contribution.

Dr R.G. Evans

Summary: **The implications of the decline in the UK's manufacturing base and its replacement by service based industries are discussed. A proper recognition of the changing nature of learning and the importance of increasing the stock and flow of highly-qualified craftpeople and technicians as well as graduates is urged.**

Introduction

We live in an interesting world at present, full of contradictory and paradoxical policies, whether these be financial or political, where this country still lacks a definitive and clearly articulated long-term strategic framework for post-16 education and training. There is still uncertainty about the future of manufacturing in this country, and how this country can improve its performance and competitiveness within the global economy.

One classic example is the future shape and purpose of manufacturing and construction in this country. Recent statistics show that major transformations are occurring in employment patterns. There are now more qualified social workers in employment than there are builders. Membership of professional associations associated with law and accountancy has gone up by almost 50%. By sharp contrast, construction has lost a quarter of its workforce and manufacturing has lost almost 800,000 jobs between 1990 and 1995. Service-based industries gained just over 200,000 jobs in that period.

The Government and its various Ministers talk enthusiastically about the need to restore the manufacturing base of the UK, but they then operate policies, for example in the areas of education and training, that weaken that endeavour. The application of a hard free-market-driven approach seriously weakens the ability of educational institutions to offer quality provision and to increase the stock and flow of highly-qualified people into certain areas of strategic importance such as manufacturing, engineering and construction. The education and training of craftpeople and technicians is equally as important as that of graduates and chartered professionals.

Decline of manufacturing

Over the past two decades we have witnessed the wholesale destruction of manufacturing in this country. Many areas of manufacture and production in which we were world leaders a few decades ago have rapidly vanished. Even accepting that many of the companies were over-staffed and operated rigid and inflexible work practices, plagued with demarcation disputes, the rate of destruction is now seen to have been disastrous and has most certainly contributed to our poor economic performance and has seriously weakened our competitive edge within the global economy.

> If one maintains a strong and viable construction industry, then one is in a position to tender for lucrative overseas contracts. A number of people who support the market economy seem reluctant to accept this rationale. It is as if they have thrown in the towel - or should it be the trowel? - completely, and are happy to allow a free deregulated market mentality to operate

Many have argued that we have reached the critical threshold and it is essential that long-term strategies are now developed to regenerate a manufacturing base, different in kind to that which previously existed, but without it this country cannot hope to compete with our competitors and will further slip down the international league tables.

This country must offer quality and value-added services and products that the rest of the world will want to purchase. Some UK-based companies are world-class and successful, but at present many are not.

Need for a balance

The financial health of any country must surely depend on a sensible balance of manufacturing and service-based industries. They must complement each other and no one element should be given undue emphasis. It has been said that the disappearance of one per cent of the manufacturing base requires a ten per cent replacement by service-based industries. This fact alone highlights the absurdity that this country can survive within a global market, reliant solely on a service-based economy. That seemed to be the political philosophy of the '80s and I believe that we are now paying the penalty for that rather shortsighted belief. Even the arguments and drive for greater inward investment are now being questioned by many commentators. After all, retrenchment could occur at any time as a result of changing political or financial priorities back in the home country. Many overseas companies who have invested in the UK often bring their own senior staff and continue to use their own home-based banks and financial services.

A number of politicians argue that it is the global economy that is the ultimate determiner of whether we have employment bases in manufacturing and construction. After all, they would argue, why should we have a domestic construction industry when one can import the expertise at lower cost? It surely does not make sense for this country to be dependent on others to build and maintain the country's infrastructure, much of which is of strategic importance. One aspect of this argument is seldom heard: after all, if one maintains a strong and viable construction industry, then one is in a position to tender for lucrative overseas contracts. A number of people I have spoken to who support the market economy seem reluctant to accept this rationale. It is as if they have thrown in the towel - or should it be the trowel? - completely, and are happy just to allow a free deregulated market mentality to operate.

Another factor which intrigues me is that, when companies declare their profits or losses and the subsequent dividends to their shareholders, great emphasis is given to the level of these dividends, or to the fact that they have significantly downsized their company and apparently increased their efficiency and productivity, but very little mention is made on the resultant impact of the recession and downsizing of companies on education and training and the development of the workforce in their companies.

It always appears that the shareholder occupies the apex of the pyramid and the last thing that is mentioned is the impact on the employees. They can be made redundant or receive little or no re-training or upskilling. One of the key flags of a world-class company is the fact that it is employee-driven and the company invests heavily in lifelong learning and retraining. This latter aspect is greatly assisted by the development of meaningful and more effective partnerships between employers and educational institutions.

Changing the nature of learning

It is now accepted that colleges and universities need to approach their work in very different ways, offering new provision, delivered in more enlightened ways, and making certain that the provision matches the needs of the employer and the changing nature of work. It is accepted that many engineers, for example, do not possess the necessary knowledge, skills and 'graces' that will be needed for the future nature of work, and to make their contribution to develop world-class companies. Lifelong learning is now essential to cope with the ever-accelerating knowledge- and skill-base and all the consequences of the global economy and greater competitiveness. The Government, and the Funding Councils, must accept that the nature of learning is being transformed and there should be a sensible and correctly differentiated funding to bring about the necessary changes and to encourage partnerships between them and the employers.

Educating and training engineers and construction people is expensive, by the very nature of the skills, knowledge and understanding that they need to acquire. There therefore needs to be a long-term strategic plan developed, properly resourced, that recognizes the elements that contribute to that high cost. Employers, too, must be helped by the Government to encourage life-long learning. This does not mean that we have to revert to the old levy system, but there surely must be other ways of offering incentives, possibly through a reformed tax regime, to companies that would allow them to accept greater responsibility to develop a more highly-qualified workforce. There are political sensitivities in this approach, and many politicians are reluctant to introduce statutory legislation. But, as the world of work changes and the influence and importance of small and medium establishments increases, it is these very companies that need financial incentives within a national framework. Recognition should also be given to the reprofiling of the workforce with its increasing emphasis on teams and the importance of increasing the stock and flow of highly-qualified craftpeople and technicians as well as graduates.

Unless action is taken, I fear that manufacturing and construction will fall below that critical threshold, and once it does it will be lost for ever and this will raise serious questions about this country's place, not only in Europe, but within the world.

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LETTER *to the Editor*

Where have all the career technicians gone?

Dr Michael Elves writes:

The recent Foundation Lecture and Dinner discussion *Whence the skilled technician?* addressed the important issue of the vanishing technician but did so from the point of view of the engineering community. This problem is, however, not one that is unique to engineering but affects many areas of scientific activity. The highly competent career technicians who were once the lynchpins for the smooth and effective running of the laboratory - whether research or routine - have now all but disappeared and cannot be effectively replaced as they retire.

The young person who would normally have seen their career following this path would have come into the organisation with good A-levels and receive training at the laboratory bench, acquiring the skills he or she would need whilst continuing with relevant academic studies at the local technology college or Polytechnic. Today these people are encouraged to take science degrees rather than pursuing technical training.

Unfortunately however, the present training an undergraduate science student receives is somewhat defficient in laboratory skills unless, of course, they have taken a year out in industry during their degree course, in which case they will have received training in the laboratory context. Graduates often emerge with their degrees but require further training from the employer to achieve the levels of practical skills that are needed for the job they are doing.

Thus the present system has resulted in the 'de-skilling' of those that would once have formed the technical backbone of the laboratory. We need to recognize that this problem exists and take steps, such as, for example, providing an up-to-date infrastructure for the teaching of modern science, to ensure that the science and technology graduates that are produced from our universities are well qualified to fulfil their roles as practising scientists, engineers or technologists.

Dr Michael Elves
Director, Office of Scientific and Educational Affairs,
Glaxo Wellcome plc

***Write to:* TI&S, Buckingham Court, 78 Buckingham Gate, London SW1E 6PE**

CHAIRMAN'S REPORT

FOR THE YEAR ENDED 31 DECEMBER 1995

Chairman: The Lord Butterworth, CBE, DL

The Foundation has enjoyed a full and varied year with 17 major meetings and three visits as well as eight seminars and workshops for learned societies.

Europe has again featured frequently in our programmes, as for instance, our joint meeting with the European Science Foundation and our visit to the European Centre for Medium-Range Weather Forecasts. However, accepting the principle suggested by Dr Richard Haas that in addition to a healthy relationship with the European Union we must also relate to the individual countries of Europe, we followed up our recent visit to Frankfurt by a highly successful visit to Paris organised jointly with the Paris Chamber of Commerce and Industry. Our principal speakers were M. Joël de Rosnay and one of our Council members, Sir Richard Sykes. Many of the team of 40 from Britain stayed for the second day to include a conducted visit to France's huge City of Science and Industry. The event in Paris was made financially possible through a generous anonymous donation. Plans are already in hand for a visit to Berlin, and a return visit from Paris to London, and the Council has this morning agreed to include in the budget a modest financial provision to supplement sponsorship for these events.

1995 also saw a continued emphasis on the Information Superhighway, which featured in many of our events. For example, we used the information highway to organise a 'global debate' at the Royal Society which included discussions with Dr Arthur C. Clarke in his study in Sri Lanka, and Deputy Secretary David Barram from Washington, both appearing live on the screen in the lecture theatre. Many will recall the outstanding contribution later that evening from Mr Martin Bangemann. There was also a visit to the Science Museum to Oracle's exhibition when visitors were invited to 'surf the net', followed by talks and a dinner discussion. The Foundation took advantage of UKERNA's demonstration of Super Janet at Imperial College, basing a seminar for learned and professional societies upon it.

We devoted evenings at the Royal Society in London to such subjects as Technology Foresight, the Research Councils a year after their reorganisation, the role of the social sciences in industry, transport and the environment, keeping world-class industrial success, the need for a national digital archive, the place of maths and science in education, employment, and various other subjects. We also helped to launch the report of 'Action for Engineering' through one of our meetings. In Scotland, at the Royal Society of Edinburgh, we held an evening on 'Land, Air and Sea, Sustainability through one Department'. We are, indeed, maintaining a full and varied programme.

The Foundation again collaborated with the Office of Science and Technology in the annual Office of Science and Technology Zuckerman Lectures when early in the year Monsieur François Fillon, the French Minister for Higher Education and Research, and later in the year Dr Ben Ngubane, South Africa's Minister of Arts, Culture, Science and Technology, gave lectures to large audiences.

The Foundation wishes to encourage younger engineers and scientists to attend the events, and already many of our Associate Members are bringing younger staff along to the lecture and dinner discussions. In addition we devoted an evening to women in science, engineering and technology which was widely popular and has brought more women to our events generally.

The important work for learned societies continued during the year with seminars and workshops, some of the latter being held in the Foundation's own small meeting room in Buckingham Court. One of the major operations has been to help learned societies through the difficult adjustments of the new Home Office Regulations and the Charity Commission's requirements concerning charity accounts. This has involved a number of workshops and seminars which appear to have been much appreciated by learned societies.

The work was assisted again by the Harold Silman Fund. I must mention, too, the help from the Royal Commission for the Exhibition of 1851 with a grant for a complete computer system.

The Foundation's two principal publications continued to thrive, the Journal under the editorship of Mr Derek Eddowes being in its eleventh year. The Learned Societies' Newsletter in its thirteenth year appears to fill an important role.

The Foundation is greatly indebted to the many who have sponsored its events, and these have been listed in the winter issue of the Journal. Their generous sponsorship and the active support of the Associate Members is at the core of the Foundation because it is they who make the activities possible. Thanks are also due to the Royal Society, the Royal Academy of Engineering and the British Academy for their support and also their donations.

Once again, I would like to thank the members of the Foundation's Council and of committees; and I would like to give a special word of thanks to Sir Richard Morris, Deputy Chairman; Roger Davidson, Honorary Treasurer; and Professor Chris Elliott, Honorary Secretary. They play a crucial part in the development of the Foundation. This year we lose Mr Oscar Roith, Mr David Andrews, Dr David Leakey and Dr Neil Cross from membership of Council and welcome Dr Bridget Ogilvie, winner of the 1994 Lloyd of Kilgerran Prize, Dr Geoff Robinson, and Sir Ronald Oxburgh.

Finally, I would like to thank our small staff of David Hall, Jennifer Grassly and Lucy Stopford and recognise the invaluable support from Chris Staffurth with the book-keeping, Derek Eddowes with the Journal, and Derek Harding with help to the Foundation and learned societies over information technology.

With continuing change and development in the Foundation, I am sure we can look forward to another successful year fulfilling our role in science, technology, engineering and industry.

FOUNDATION FOR SCIENCE AND TECHNOLOGY
STATEMENT OF FINANCIAL ACTIVITIES
FOR THE YEAR ENDED 31st DECEMBER 1995

	Unrestricted Funds	Restricted Funds	1995	1994
INCOME AND EXPENDITURE	£	£	£	£
Incoming resources				
Donations	21,112	-	21,112	11,020
Sponsorship income	104,673	-	104,673	132,004
Accreditation fees and subscriptions	102,476	-	102,476	93,292
Learned societies activities	11,550	-	11,550	9,818
Fixed asset grant	967	-	967	1,500
Listed investment income	8,019	-	8,019	7 ,110
Bank deposit interest	15,140	580	15,720	12,524
Total incoming resources	263,937	580	264,517	267,268
Resources expended				
Direct charitable expenditure	162,834	170	163,004	154,969
Management and administration	54,125	-	54,125	58,394
Total resources expended	216,959	170	217,129	213,363
Net incoming resources for the year	46,978	410	47,388	53,905
Other recognised gains and losses				
Unrealised gains/(losses) on investment assets	14,289	-	14,289	(17,982)
Net movement in funds	61,267	410	61,677	35,923
RETAINED SURPLUS BROUGHT FORWARD AS RESTATED	418,047	10,219	428,266	392,343
RETAINED SURPLUS CARRIED FORWARD	479,314	10,629	489,943	428,266

TOTAL RECOGNISED GAINS AND LOSSES
The company has no recognised gains or losses other than the surplus or deficit as shown above and the prior year adjustment.

CONTINUING OPERATIONS
None of the company's activities was acquired or discontinued during the accounting periods shown above.

FOUNDATION FOR SCIENCE AND TECHNOLOGY
BALANCE SHEET
AS AT 31st DECEMBER 1995

		1995		1994	
		£	£	£	£
FIXED ASSETS					
Tangible assets			9,085		4,566
Investments			337,112		122,773
			346,197		127,339
CURRENT ASSETS					
Debtors		14,340		39,371	
Cash at bank	- on deposit	114,157		256,125	
	- current account	25,146		27,691	
	- The Harold Silman Fund	10,347		10,354	
Cash in hand		136		91	
		164,126		333,632	
CREDITORS					-
amounts falling due within one year		20,380		32,705	
NET CURRENT ASSETS			143,746		300,927
TOTAL NET ASSETS			489,943		428,266
Financed by:					
FUNDS					
Unrestricted			479,314		418,047
Restricted			10,629		10,219
			489,943		428,266

The accounts for the year ended 31 December 1995 have been prepared in accordance with the new Home Office Regulations, and the Charity Commission guidance of the Statement of Recommended Practice (SORP 2). Hence there is the new 'Statement of Financial Activities'.

Copies of the full accounts can be obtained from the Foundation for Science and Technology, Buckingham Court, 78 Buckingham Gate, London SW1E 6PE.

Approved by the Council on 13th March 1996

THE LORD BUTTERWORTH
Mr R.G.L. DAVIDSON } COUNCIL MEMBERS

SPONSORED LECTURES, LEARNED SOCIETY SEMINARS AND FOUNDATION VISITS

1 SEPTEMBER 1995–31 MAY 1996

LECTURE TITLE	SPEAKERS	SPONSORED BY
UK Industrial Revival - 'The Engineering Community's Action for Engineering'	Mr Robert Margetts, F.Eng. Professor Arthur Francis Mr Alastair Macdonald	The Engineering Council Department of Trade and Industry
'Research, Collaboration and Competitiveness in Industry: Perspectives in Germany and the UK'	Professor Dr Joachim Treusch Dr Peter Williams, CBE Professor Dr Hartmut Weule	Foundation's Shared Sponsorship Scheme
'Do Government and Industries' Scientists and Engineers Listen to Public Opinion?'	Professor Robert M. Worcester Sir John Egan Professor Lewis Wolpert, CBE FRS	COPUS Zeneca plc
'Science, Industry and Government. The Place of Pressure Groups'	Mr Jonathon Porritt Mr J.G. Speirs Sir Crispin Tickell, GCMG, KCVO	
'Human Genetics, Ethics, Society and Legislation'	Sir Giles Shaw MP Professor Peter S. Harper Dr Helen Watt	The Kohn Foundation Office of Science and Technology Pfizer Central Research The Wellcome Trust Zeneca Group plc
'Sustainable Development - How Can Industry Manage its Environmental Liabilities?'	Mr F.A. Osborn CB Mr Rodney Chase Mr Georges Kremlis	British Nuclear Fuels plc Brown & Root Environmental Department of the Environment Railtrack plc The Royal Commission on Environmental Pollution
'Nutrition - How Do We Get the Right Messages?'	Professor Alan D.B. Malcolm Professor Philip James, CBE, FRSE Miss Gill Fine	Ministry of Agriculture, Fisheries and Food
'Investing in Growth Issues for Technology-based Firms'	Mr Duncan Matthews Dr Bob Bishop Mr Richard Drury Mr M. Powell	National Westminster Bank plc Department of Trade and Industry
'Younger Scientists and Engineers. It's Their Future'	Dr Tracey Turner Dr Mark Cliverd Mr Rikard Andersson Mr Adrian Colyer Ms Alexandra Walker Dr Steve Young	Glaxo Wellcome plc IBM United Kingdom Limited The Smallpeice Trust
'Whence the Skilled Technician?'	Mr John Spensley Mr Victor Lucas Dr R.G. Evans	The Engineering Council The Engineering Training Authority
'Properly Harnessing the Information of the Future. Can we?'	Mr Kenneth Bagnall, QC Major General Edmund Barton, OBE Professor Ray Harris	The New Law Publishing Company plc

FOUNDATION TECHNOLOGY VISITS

La Cité des Sciences et de l'Industrie - Paris.

The Rutherford Appleton Laboratory, Chilton, Oxfordshire.

SEMINARS FOR LEARNED SOCIETIES

Branches - Post SORP2

New Accounting Regulations for Charities and their application through SORP2

The Learned Society, Journals and the Internet

Asset or Liability? Exploiting every inch yet knowing the law

ASSOCIATE MEMBERS & MAJOR DONORS

Whose support of, and involvement in, the affairs of the Foundation is gratefully acknowledged

1 JUNE 1996

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Nottingham Trent University
Nuclear Electric plc
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