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THE STEM PROGRAMME IN ENGLAND

Help or hindrance for design & technology education?

INTRODUCTION

This chapter is in four parts. It is deliberately and of necessity descriptive. And the author has to acknowledge that in reporting this very short history of an episode of curriculum politics that he was actively involved in the machinations. The author is the STEM (science, technology, engineering and mathematics) consultant for the Design & Technology Association and was given the brief to develop the profile of design & technology within the National STEM Programme with particular reference to links with science. In Part 1 the chapter reports on the rationale for and progress made so far in the national STEM programme. Part 2 describes the efforts made by the Design & Technology Association, the professional association for design & technology teachers in England, to enable the school subject design & technology to be considered as an essential part of the "T" in STEM. Part 3 describes the in-service programme for design & technology teachers that is emerging as part of the National STEM Programme and the infrastructure that is supporting this. Part 4 discusses the implications of the unfolding developments within the National Stem Programme for the future of design & technology.

THE NATIONAL STEM PROGRAMME

The National STEM Programme has its roots in the report to the Government by Sir Garth Roberts *SET for success The supply of people with science, technology, engineering and mathematics skills*, April 2002, and the report by Lord Sainsbury of Turville *The Race to the Top: A Review of* Government's *Science and Innovation Policies*, October 2007, both of which indicate the need for more pupils to gain qualifications in science and mathematics.

> Scientists, mathematicians and engineers contribute greatly to the economic health and wealth of a nation. The UK has a long tradition of producing brilliant people in these areas, from Isaac Newton and Isambard Kingdom Brunel, to Dorothy Hodgkin and Neville Mott last century, and most recently to Andrew Wiles who proved Fermat's Last Theorem. The challenge we face is to continue to attract the brightest and most creative minds to become scientists and engineers. (Roberts, 2002 p..iii)

M.J. de Vries, Positioning Technology Education in the Curriculum, 63–74.

> Demand for science, technology, engineering and mathematics (STEM) skills will continue to grow. The UK has a reasonable stock of STEM graduates, but potential problems lie ahead. There has been a 20-year decline in the number of pupils taking A-level physics. The Review recommends a major campaign to address the STEM issues in schools. This will raise the numbers of qualified STEM teachers by introducing, for example, new sources of recruitment, financial incentives for conversion courses, and mentoring for newly qualified teachers. The Government should continue its drive to increase the number of young people studying triple sciences, and consider entitlement for all pupils to study the second mathematics GCSE (due to be introduced in 2010). (Sainsbury, 2007 p. 6)

In direct response to these reports the government produced a report The Science, Technology, Engineering and Mathematics (STEM) Programme Report (Department for Education and Skills and Department for Trade and Industry (DFES & DTI), 2006). As the following quote reveals the government had decided to rationalise the range of STEM initiatives and initiate a national strategy.

> However, at the current time we have far too many schemes, each of which has its own overheads. The original STEM Mapping Review in 2004 revealed over 470 STEM initiatives run by DfES, DTI and external agencies and subsequently, the STEM cross cutting programme examined around 200 of these. They are not, therefore, in total either efficient or effective and do not give a complete coverage of all schools. We need, therefore to rationalise those supported by the Government and build on the best ones. By doing so, we believe we can achieve a much better result for the same amount of money. Our proposals work towards a vision that aims to ensure that STEM support is delivered in the most effective way to every school, college, learning provider and learner. For the first time we will have: One high level STEM Strategy Group that will join up STEM across all phases of education and make recommendations to Ministers about national STEM priorities; and a National STEM Director who will drive delivery forward. (DFES &DTI, 2006 p.3)

The report makes sorry reading for the design & technology community. The report had virtually ignored design and technology. The only reference to the subject was as follows:

> It should be noted that engineering and technology are not typically considered as curriculum subjects in schools – though design and technology and ICT may count as such – but they are often college subjects. (DFES &DTI, 2006 p.10)

On what planet did the authors of this report reside, one wondered? To compound the situation the Report did not mention the Design and Technology Association as a partner which might take part in developing the T aspect of STEM. This was not an auspicious start.

Table 1. The STEM National Programme

Action Programme	*Lead Organisation*
Getting and training the right teachers and lecturers of STEM subjects in the first place	
AP1 Improving the recruitment of teachers and lecturers in shortage subjects	Training and Development Agency for Schools (TDA)
Providing the right continuing professional development for teachers of STEM subjects	
AP2 Improving teaching and learning through CPD for mathematics teachers	National Centre for Excellence in the Teaching of mathematics (NCETM)
AP3 Improving teaching and learning through CPD for science teachers	National Science Learning Centre (NSLC)
AP4 Improving teaching and learning by engaging teachers with engineering and technology	Royal Academy of Engineering (RAEng)
Providing the right activities and careers advice that bring real world context and applications of STEM into the classroom	
AP5 Enhancing and enriching the science curriculum	Science Community Representing Education (SCORE) is convened by the Royal Society. The other founding partners are the Institute of Physics, the Royal Society of Chemistry, the Institute of Biology, the Biosciences Federation, the Science Council and the Association for Science Education
AP6 Enhancing and enriching the teaching of engineering and technology across the curriculum	Royal Academy of Engineering (RAEng)
AP7 Enhancing and enriching the teaching of mathematics	Advisory Committee on Mathematics Education (ACME)
AP8 Improving the quality of advice and guidance for students (and their teachers and parents) about STEM careers, to inform subject choice	The National STEM Careers Co-ordinator (at Sheffield Hallam University)
Getting the STEM curriculum in the classroom right	
AP9 Widening access to the formal science and mathematics curriculum for all including access to triple science GCSE	Department for Children, schools and Families (DCSF)
AP10 Improving the quality of practical work in science	SCORE
Getting the STEM education support infrastructure right	
AP11 Programme to build capacity of the national, regional and local infrastructure	Department for Children, schools and Families (DCSF)

John Holman was appointed National STEM Director and under his leadership an action plan for the national programme was developed. organised into 5 themes and involving 11 action programmes overall with each action programme supported by a lead organisation (National Science Learning Centre 2008). This is summarised in Table 1. Inspection of the individual action programmes that comprise the national programme reveals a dominance of mathematics and science. Some commentators have described the programme as a SM programme as opposed to a STEM programme. The complete absence of the phrase design & technology is an obvious cause of concern for those who believe that this school subject can make a significant contribution. However, there are action programmes which can be aligned with and include design & technology and it was through this approach that the Design & Technology Association embarked on the process of raising the profile of design & technology.

ELABORATING THE T IN STEM

The situation with regard to the absence of design & technology was rectified to some extent by the report *S-T-E-M Working Together for Schools and Colleges* based on the outcomes of a workshop held at the Royal Society in May 2007 (Royal Society 2007). Richard Green, Chief Executive of the Association, was invited to make a presentation about design & technology in schools to an audience of STEM stakeholders. The response was positive and the resulting seminar report identified benefits of science, design & technology and mathematics working in a co-ordinated way, acknowledged that prevailing 'performance culture' forced teachers to operate in subject silos noting that the challenge was "how to bring about change while working within the existing performance culture" (p.2). Significantly the report noted that to make the most of the possibility afforded by the opportunity to establish a STEM education community "pulling in the same direction" it will be necessary:

> to avoid any suggestion of a 'top down' approach - all members of the community need to be treated as autonomous players;
>
> to foster a culture of co-operation, not competition;
>
> for co-ordinating bodies such as SCORE and the Science Learning Centres to recognise that they need to earn respect from organisations that have been around for a lot longer; (Royal Society 2007, p. 4/5)

This clearly opened the way for a fuller involvement of the Design & Technology Association and as a result of this the author was able to interview the authors of the report, Michael Reiss (at the time Director of Education for the Royal Society) and John Holman, for the Association and for the interviews to be published in D&T News and to appear on line (Barlex 2007a, 2008). Both interviews revealed a strong willingness on the part of these two highly influential science educators to support design & technology as a key player within the STEM programme. In response to the question "What is it that you think science might learn from design & technology?" Michael Reiss said

> When I look at the work secondary school students undertake in D&T, there are two things that stand out for me as lessons that science educators might learn. The first is the time given to designing, undertaking and evaluating a

> piece of work. One of the great sadnesses for me of the introduction of the science National Curriculum has been how we have failed to help students understand, by the time they reach the age of 16, how science is undertaken. The second … is the importance of values as being integral to every subject. There has been a tendency for some science courses to assume that values can either be ignored or treated as a sort of soft add on after all the hard science has been done. It is precisely that failure that leads so often to scientists failing to understand UK public attitudes, whether about GM crops (most people against them whatever the safety arguments) or recycling (everyone in favour of it but only 10% prepared to do anything about it unless they are forced to or it is in their own interests). Regretfully, most school mathematics is undertaken as if in a values vacuum – as if it doesn't matter whether calculated rates of change over time are for interest rates, unemployment rates or infant mortality rates. (D&T News September 2007 p.18)

In response to a question concerning the concentration on mathematics and science and the apparent disregard of design & technology John Holman explained the importance of science and mathematics both in their own right and as gatekeeper subjects for a wide range of STEM careers and importantly acknowledge that "… the low profile of design & technology does represent a lost opportunity … the role of design & technology to provide a hands on technological and engineering is very important" (D&T News April 2008 p.19)

So the stage was set for the Design & Technology Association to play a fuller part and this was achieved by the author and Richard Green suggesting to John Holman that it was important for the Design & Technology Association to be seen to be consulted, as opposed to just working behind the scenes. This resulted in John working with Matthew Harrison of the Royal Academy of Engineering (RAEng) to arrange for the Design & Technology Association to be officially invited to join the 5–19 STEM Programme Board. Hence the Association was now seen as a representative body along with the Association for Science Education, the Royal Academy of Engineering, the Royal Society and the Research Councils UK. The Design & Technology Association were now in a position where it could collaborate officially with other representative bodies and this enabled Richard Green to work with Matthew Harrison to make a submission to the STEM High Level Strategy Group (HLSG). The RAEng and the Design and Technology Association were tasked by the Department for Children, Schools and Families (DCSF) to produce a paper for the STEM HLSG meeting on 17 October 2008. This paper, *D&T: a remit for the future* built on the Offiice for Standards in Education (Ofsted) recommendations (Ofsted 2008). Having received the paper, the STEM HLSG asked that RAEng and the Design & Technology Association convene a working group to (a) identify how Design and Technology [D&T] could further support the STEM Programme goals and targets, (b) identify and prioritise what support and development within D&T would be necessary to do this and (c) identify the likely costs. Via a stakeholder meeting and the follow up work of a virtual sub group of which the author was part a briefing paper was developed and presented to the HLSG (Wright, 2008). The paper contained the following recommendation.

> The HLSG should recognise and support the requirement for D&T-led CPD provision to make mathematics and science concepts explicit in D&T teaching and learning at both Primary and Secondary phases. This may be achieved through D&T-led CPD focusing on designing informed by mathematics and science starting with, but not restricted to electronic/control product design incorporating systems thinking. (Annex C)

At this stage it remained to be seen whether this recommendation would have any effect.

THE EMERGING IN-SERVICE PROGRAMME

Whilst the Design & Technology Association was working to position itself as a body of influence with the HSLG it was also developing the digital design & technology programme. This programme was formulated by the Design & Technology Association to bring together in a coherent manner those elements of design & technology that made strong use of information and communication technology. This involved amalgamating two very successful existing programmes – the CADCAM initiative and the Electronics in Schools strategy. The result of this amalgamation has been the setting up of four support centres in each of the government regions in 2008. Two of these centres have expertise in electronics and two have expertise in CADCAM. In some of the regions this expertise is combined within a singe centre. These centres receive modest funding from the DCSF, guaranteed for three years and have the brief of providing in-service training concerning the application of digital technologies to design & technology according to local needs. Over the following three years the training pattern was expected to shift from 75/25 dedicated/integrated sessions to 25/75 dedicated/ integrated session i.e. teachers will be progressively empowered to adopt and teach a digital approach to electronic product design. Importantly there is a science learning centre (SLC) in each region so there is the possibility of these support centres working ever more closely with the SLC and providing in-service training that enables science and design & technology teachers to coordinate their work as recommended by the report S-T-E-M Working Together for Schools and Colleges (Royal Society 2007).

It was possible to use Action Programme 6 *Enhancing and enriching the teaching of engineering and technology across the curriculum* to develop a pilot programme of in-service training aimed at enabling science and design & technology teachers to work together. The theme for this pilot was modern materials and Professor John Cave of Middlesex University was commissioned to identify and source at reasonable cost a selection of such materials that would provide interesting materials investigation and application possibilities thus appealing to teachers from both disciplines. The contents of the set are listed in

Table 2. Representatives of digital design & technology support centres and science learning centres met together to explore the materials and plan possible in service programmes. These programmes were advertised through the science learning centre network but uptake proved to be very small.

Table 2. Content of Modern Materials Kit

Thermally responsive materials	Smart alloys and polymers	Optically responsive materials and LEDs
Thermochromic pigment Thermofilm Thermal paper (fax) Phase change powder	Shape memory polymer Smart putty Rare earth magnet Superelastic wire Memory wire 2-way memory spring	Glow-in-the-dark film Opical fibre UV fluid UV beads LEDs
Fibres and woven materials	Special polymers	'Nano' materials
Cocoons Chopped carbon fibre Kevlar fabric Carbon fibre fabric Ripstop nylon Silk Lycra Eco film Genuine carbon fibre sheet	Polymorph Hydrogel Expancel Chromatic alginate	QTC pills Broken shells Bank of England money Chameleon nano flakes Smart film

Whilst this was taking place the HLSG had considered the recommendation developed by the Royal Academy of Engineering and the Design & Technology Association. The Royal Academy of Engineering offered to part-fund the recommendations with the result that the DCSF was instructed by Ministers to match fund the initiative under Action Programme 6. A total of approximately £360k available over three years was made available. At a meeting convened by John Holman at the National Science Centre in York key players discussed possible ways forward. The following were identified.

The in-service training would be available in all regions of England. The programme would be made available through both the regional science learning centres and their associated digital design & technology centres. The technical content of the in-service was identified in the first instance as focusing on systems and control featuring in particular actuation from initial thoughts tabled by Andy Mitchell of the Design & Technology Association. John Cave of Middlesex University was invited to identify and source at reasonable cost appropriate materials, components and equipment. The in-service training will be piloted with a small group of teachers over the summer term of 2009 before becoming the basis for a significant train-the-trainers event to take place in mid September 2009. This would allow for the programme to be disseminated widely through 2010. Melanie

Washington of the Royal Academy of Engineering indicated that her organisation would be able to bring strong industrial links to the applications within the courses. Pat Hughes and the author agreed to work on a parallel development in which teachers would attend the BT research and development centre at Adastral Park and become familiar with new and emerging communication technologies that they could then use in engaging pupils with developing applications for such technologies.

DISCUSSION

From a position in 2004 in which design & technology as a school subject was ignored and seen as having little if any contribution to make to the STEM programme the situation has changed. Through the work of the Design & Technology Association professional relationships were forged with figures of influence in the STEM community, particularly John Holman, the National STEM Director and Matthew Harrison, Director of Education at the Royal Academy of Engineering. The nature of design & technology and its potential to make a significant contribution was clarified and this contribution was acknowledged by the STEM High Level Strategy Group with the result that some modest funding has been made available for in-service training for design & technology teachers. This has been accompanied by the development of a national network of design & technology support centres which can work closely with the network of regional science leaning centres. Given this new position of design & technology what is the possible trajectory for the subject in the future?

To maintain its influence it is likely that design & technology will have to demonstrate the effective use of science and mathematics within the teaching and learning of design & technology so that pupils a) experience the utility of these subjects and b) are motivated to continue studying them post 16. Ainley, Pratt and Hansen (2006) made the argument for the utility of one subject informing purposeful activity in another subject with regard to the utility of mathematics. This argument has been extended by Barlex (2007b) to show the potential of cross-curricular links between design & technology, mathematics and science to enhance pupil's design activity. However the history of interaction between subjects in the secondary school curriculum has shown that this is not easy to achieve. Barlex and Pitt (2000) reported that there was little if any interaction between science and design & technology in the secondary school and that this was confounded by an erroneous perception of each subject by those teaching the other subjects. A later report (Barlex 2005) indicated that within secondary schools in England designated as Engineering Colleges this situation had not changed significantly. A small case study (Lewis et al 2007) indicated that the misunderstanding identified by Barlex and Pitt (2000) led to antagonism between the science and design & technology teachers and failure in cross-curricular activities. However with the introduction of a new programme of study for the National Curriculum in England at Key Stage 3 (pupils aged 11 – 14 years) in 2008 (Qualifications and Curriculum Authority (QCA), 2008a) there is the possibility that the situation in schools may become more conducive to cross curricular work in which individual subjects work together tackling topics which are interdisciplinary in nature. The desirability of such activity has been made even more explicit by the publication by QCA of the BIG Picture (QCA 2008b) which describes a range of whole curriculum dimensions which require collaboration between different subjects. Recently Sharkawy et al (2008) identified a set of seven criteria which needed to be met if such cross curricular work involving science, mathematics and design & technology were to be successful. Since late 2007 the Nuffield Foundation has been operating a Key Stage 3 STEM project (see www.nuffieldstem.org) which aims to provide teachers with the means to develop interdisciplinary STEM activities involving mathematics, science and design & technology. So in terms of the curriculum at Key Stage 3 there is now a positive environment and developing expertise to help schools engage in cross-curricular STEM activities in which design & technology plays a significant part. It is worth noting that interaction between pupils understanding of mathematics and science and their learning in design & technology is not necessarily dependent on cross-curricular activities. It is feasible that a design & technology teacher might deliberately develop designing and making tasks which call heavily on science and mathematics for successful completion and 'fly solo' in the actual teaching. It would of course be unwise to do this without first engaging in conversation with those who teach the pupils science and mathematics. Whether the design & technology teachers operate independently but in consultation with their science and mathematics colleagues or become part of cross curricular teams which plan and teach collaboratively the future status of design & technology is likely to be dependent to some extent on the effect that the teaching has on pupils attitude towards and ability in mathematics and science. John Holman (Barlex 2008) has indicated that in design & technology this can be achieved by providing a "hands-on technological and engineering experience". He lays down a challenge.

> …it's now up to design & technology teachers to get involved and show the rest of the STEM community just what a powerful role they can play.(p. 20)

Since John Holman made this remark the situation in England has changed. On 11th May 2010 a new UK Government took office. It has radical plans to change the education system. This is made clear by the following statement which appears on the extensive website of the previous administration.

> A new UK Government took office on 11 May. As a result the content on this site may not reflect current Government policy. All statutory guidance and legislation published on this site continues to reflect the current legal position unless indicated otherwise. To view the new website, please visit http://www.education.gov.uk

With regard to the National Curriculum (Department for Education (DfE) 2010) the intention is:

> …to restore the National Curriculum to its original purpose – a minimum national entitlement for all our young people organised around subject disciplines. Ministers are committed to giving schools more freedom from unnecessary prescription and bureaucracy. Ministers have always made clear their intentions to make changes to the National Curriculum, to ensure a focus on the basics and to give teachers more flexibility …

These plans must be put in the context of decreasing public expenditure in response to the global economic crisis and the need to reduce the budget deficit.

There are two concerns for the design & technology community arising from this new situation. First is responding to the organizing principle of subject discipline. Design & technology does not easily meet the usual criteria for being a school subject discipline. As Kimbell and Perry (2001) assert it has "an awkward insistence on being neither a specialist art nor a specialist science. It is deliberately and actively interdisciplinary. It is creative, restive, itinerant, non-discipline" (p.6). Second is the availability of funding for continuing professional development that is essential for the modernization of the design & technology curriculum. This was raised in parliamentary question time and received the following answer (Hansard 12 July 2010) from the Parliamentary Under-Secretary of State for Education (Tim Loughton).

> I agree with the hon. Member for Huddersfield (Mr Sheerman) that the quality of teachers and professional development is important. International evidence shows that teachers learn from observing good teachers, and this happens best in schools. That is why the Government are committed to encouraging schools to demonstrate a strong culture of continuing professional development, with teachers leading their own development and that of others, and sharing effective practice within and between schools. That is why we are currently reviewing our policies and existing activities to ensure that they focus on that vision. (Columns 650 and 651)

This view of professional development does not engage strongly with the need of design & technology teachers to regularly upgrade their subject knowledge in a rapidly changing field. This will not occur through observing other teachers however gifted the practitioners that are observed.

At the time of writing the future is unclear. To some extent design & technology is protected by being considered as part of STEM with the government seeing a rise in wealth creation through manufacturing and exports as part of the UK economic recovery (See for example Wall Street Journal 2010). However, this utilitarian view of the contribution to education made by design & technology is limited and could if taken to extreme undermine the position of the subject as a feature of general education for all pupils.

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