Dear Minister, This is why design and technology is a very important subject in the school curriculum

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Abstract
The paper is in four parts. Part 1 considers the justification for including design and technology in the school curriculum. Part 2 suggests the content for the subject at Key Stage 3. Part 3 describes some of the ways the subject might be taught. Part 4 considers ways in which the curriculum can be devised so that it is irresistible and transformative. A brief conclusion revisits the unique characteristic of the subject.

Key words
curriculum, curriculum development, design and technology, pedagogy

Introduction
At this time of writing design and technology is surrounded by uncertainty. Will it be part of the new National Curriculum and if so at what key stages? Will it have a statutory programme of study or just non-statutory guidelines? Will it be recognised at Key Stage 4 within a Baccalaureate suite of some sort or not?

Whatever the answers to these questions it has never been more essential that those involved in teaching design and technology can argue convincingly for its place in the curriculum. The lecture is in four parts. First I will present an educational rationale for the subject. Second I will outline content appropriate for the subject. Third I will describe ways to teach the subject in the context of meeting the needs of young people who are living in an advanced technological society at the beginning of the 21st Century. Finally I will discuss features which need to be considered in order to develop an irresistible and transformative design and technology curriculum.

Four justifications
I justify the inclusion of design and technology in the National Curriculum by means of four considerations. The first justification concerns cultural significance. According to Jacob Bronowski being technological is a defining human activity. In his seminal work 'The Ascent of Man' (Bronowski 1973) he described this unique achievement of our species as follows.

Man is a singular creature. He has a set of gifts, which make him unique among animals; so that, unlike them, he is not a figure in the landscape – he is a shaper of the landscape (page 19).

He captured the nature of this accomplishment in three brilliant sentences.

The hand is the cutting edge of the mind. Civilisation is not a collection of finished artefacts; it is an elaboration of processes. In the end the march of man is the refinement of the hand in action (page 116).

Design and technology is the only subject in the current National Curriculum that embodies this activity and provides learners with the experience of 'the hand in action'.

The second justification concerns the way in which young people become effective. Design and technology is unique in the school curriculum in that it poses pupils with practical challenges to which there is no single 'right answer' and require creativity and technical competence. This develops self-esteem and self-efficacy, a can do approach which sees the world as a place of opportunity where people are not at the mercy of their surroundings. It is well established that a positive perception of self-efficacy is a pre-requisite to a successful career in highly competitive industries, whatever the sector (Bandura 1997).

The third justification concerns the contribution of design and technology to economic recovery. The design and manufacture of innovative products for global markets is seen as a major plank in the policy towards economic recovery and Vince Cable (2011) the Business Secretary has stated unequivocally that British industry need to attract the brightest and the best to manufacturing. The Chancellor of the Exchequer in his most recent Budget Speech said, *"We want the words 'made in Britain, created in Britain, designed in Britain, invented in Britain' to drive our nation forward"* (Osborne 2011). Design and technology is the only subject in the current National Curriculum that provides learners with an introduction to modern design and manufacture. The subject also gives young people an authentic taste of a technical career and hence provides a conduit into vocational education for a variety of purposes – craftsperson, technician, and graduate engineer. Without such experiences young people will not be predisposed to enter such careers. The prospect of attending a University Technical College (Baker & Mitchell 2010) may become unappealing and the eloquent case made by Professor Alison Wolf (Wolf 2011) for an increase in modern apprenticeships might flounder.

The fourth justification concerns the contribution of design & technology to engaging with global challenges. It is generally agreed that technology creates solutions that create problems which require further technology to solve (Arthur 2009, Kelly 2010). We are not short of challenges for which technology may be invoked to develop responses as the following list indicates:

- Climate change
- Resource depletion
- Resource distribution
- Health and wellbeing
- Energy supply
- Transport
- Information availability and reliability

Design and technology is the only subject in the current National Curriculum that inspires learners with the practical foundations that will lead some pupils into careers that develop technological solutions to global challenges.

In response to each of the four identified considerations I have argued that design and technology provides a unique contribution. Taken together it would seem that the case for teaching all young people this subject, whatever their career aspirations, is extremely robust. This does of course require that those who decide on the education of our young people see it as the responsibility of school education to engage with these considerations i.e. induction into a practice that is uniquely human, development of self efficacy, of economic significant and encouraging a proactive response to global challenges. It seems self-evident to me that this is something to which school education should aspire. It is essential that those in power can be persuaded to this view as well.

The current Minister of Education, Michael Gove, has decided that it is crucial to identify the essential knowledge that children need in order to progress and develop their understanding. He sees this understanding as being categorized under four headings: facts, concepts, principles and fundamental operations (Department for Education 2011). This presents design and technology with a significant challenge. Whilst understanding is of course essential in design and technology this is not its primary purpose. The primary purpose is to develop the ability to “intervene effectively and creatively in the made world” (Department for Education and Science and the Welsh Office 1988). So it is to the question of defining the content of design and technology in this light that I now turn.

A question of content

The four features required by the Minister should not be considered in isolation. The meaning of the key elements of knowledge is informed by the key concepts. These in turn underpin the key principles which are enacted through the fundamental subject specific operations and skills. Hence I present an initial response to this ministerial challenge which takes into account this relationship. This has been developed through a collaborative conversation between the author, Torben Steeg, Nick Givens, James Pitt and Paul Anderson. Whilst it is a considered response it should not be seen as in any sense definitive but as a statement offered for constructive criticism and modification in the process of developing a rigorous statement of design and technology in the revised National Curriculum. It begins by providing statements for the key concepts and identifying the key elements of knowledge that relate to these concepts for Key Stage 3. It then identifies the key principles and briefly describes their relationship with concepts and knowledge. Finally it identifies the fundamental subject-specific operations and skills and describes how they are used in response to the key principles.

Key concepts and associated key elements of knowledge

Seven key concepts relevant to design and technology are identified and developed into broad descriptions that define the key concepts in ways that are of use across Key Stages 1 – 3 and lay the basis for progression into GCSE design and technology courses and the engineering diploma. The key concepts are designing, making, resources and their characteristics, control, structures, systems and systems thinking, and the designed and made world.

Designing is the act of generating, developing and communicating ideas for products, services, systems and environments in response to user needs and wants and/or market opportunities. Both digital and traditional design tools may be used. Design activity will call upon well-established bodies of knowledge including technical knowledge based on science and mathematics and also require the generation of new knowledge specific to the design task in hand. Pupils will design for a wide range of users in varied situations.

Key elements of knowledge for designing at Key Stage 3 include the following:

- A design brief is a short statement describing some or all of the following; the sort of product to be made and its purpose, who will use it, where it will be used and where it might be sold. An open brief provides general guidelines with the opportunity for a wide range of possible outcomes. A closed brief is more specific and detailed in its requirements

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- A specification describes what a product has to do. It may also describe what the product should look like, whether it should work in a particular way and any legal or environmental requirement the product must meet
- Strategies such as attribute analysis, brainstorming, morphological analysis, observation of nature and connecting 'disparates' can be used to generate design ideas
- Disassembling complex products can be used to generate and explore design ideas
- Sophisticated sketching techniques with annotations can be used to generate, develop and communicate design ideas
- Experimenting with and investigating ingredients and simple 2D and 3D modeling can be used to develop and communicate complex design ideas
- Sophisticated CAD software can be used to model the appearance and function of complex designs

Making is the act of realising design ideas through the use of hand tools, machine-tools and computer-controlled equipment. Pupils will make using a wide range of materials including food, textiles, wood, metal, plastics, composite, technical components and modern and smart materials

Key elements of making at Key Stage 3 include the following:
- Simple hand tools and machine tools can be used to cut, shape and combine materials, ingredients and components
- Computer driven equipment can be used to cut and shape materials
- Computer driven equipment can be used to print complex forms according to digital designs

Resources in the form of energy, materials, ingredients and components (including those based on modern materials) are utilized in the production and use of products, services, systems and environments. These resources have characteristics that define and limit their potential application.

Key elements of resources and their characteristics at Key Stage 3 include the following:
- Energy can be derived from both renewable and non-renewable sources and can be stored and managed in ways that make it available to power a wide range of systems and artefacts
- Materials and ingredients have physical, chemical and nutritional properties that govern their performance characteristics, aesthetic qualities and the means by which they can be manipulated. Components have particular performance characteristics which govern their uses.

Devices work can be controlled by mechanisms, electrical circuits and programmable electronics.

Key elements of control at Key Stage 3 include the following:
- The use of mechanisms to control both force and movement;
- The use of switches in circuits to control multiple actuators;
- The use of graphical or text based programming language to control actuators in response to sensors;
- The design circuits for use with microcontrollers.

Structures are assemblies of materials and components that enclose spaces and support loads. They vary in size, complexity and purpose

Key elements of structures at Key Stage 3 include the following:
- The use of paper, card, wood, textiles, metals and plastic to design and make 3D objects to act as structures
- The structural elements within foods to achieve aesthetic qualities

A system may be defined as a combination of related parts organised into a complex whole. Understanding the relationship between the parts allows the behaviour of the system to be modelled. Systems thinking allows complex entities to be considered at different levels of detail according to the purpose of the consideration.

Key elements of systems and systems thinking at Key Stage 3 include the following:
- A control system can be described in terms of input process output;
- Feedback can be used to control the behaviour of a system;
- Systems thinking can be used to describe the workings of organizations such as hospitals or retail outlets;
- Infrastructure such as transport or energy supply can be described in terms of systems;
- Complex problems such as lifecycle analysis, food production and supply or water supply can be described in terms of systems.

The made world comes into existence through the design and manufacture of all the products, services, systems and environments that we use in our day-to-day lives. The consequences of these activities always have impact beyond their intended benefits in both the made and natural worlds. Markets are the means by which the made world becomes available to users. The development and success/failure of such outcomes may depend on the extent to which they meet users needs and wants, their acceptability to society and the extent to which there is investment in their production.

Key elements of the designed and made world at Key Stage 3 include the following:
- People use products, services and systems to help them with their day-to-day activities;
- The work of designers, technologists and engineers in the past and today make significant differences to the way we can live our lives;
- Successful innovation requires that products and services are introduced to markets and are adopted by consumers in large numbers. The market for such products and services then grows, matures and eventually decline as they are replaced by new innovations;
- New and emerging technologies e.g. nanotechnology, genetic modification of plants and animals, 3D printing, augmented reality and programmeable materials provide opportunities for the development of new products, services, systems and environments which will impact on our lives in ways that are both predictable and unpredictable and can be both beneficial and harmful.

Key principles

The following six key principles relevant to the teaching of design and technology. Have been identified.

1. Through design and technology humans intervene in the made world (both real and virtual) and impact on the natural world
2. Such interventions should show fitness of purpose and lead to fitness for purpose
3. Such interventions may be in response to user needs and wants and/or market opportunities
4. Such interventions may consume resources in a linear economy or preserve resources in a circular economy
5. Such interventions will require the choice and use of appropriate resources, tools and methods
6. Design and technology activity always has economic, social and environmental consequences.

These key principles define design and technology as an activity that is concerned with 'taking action' as opposed to 'developing explanation', and identifies the purposes, drivers, means and consequences of taking action. The learning of the concepts and associated key elements of knowledge outlined above is necessary if pupils are to take action according the key principles.

Fundamental subject-specific operations and skills

The following five fundamental subject-specific operations and skills relevant to design & technology have been identified:

1. Designing

This requires strategies for identifying users needs and wants, generating design ideas, developing and communicating design ideas, and planning.

2. Making

This requires techniques for using hand tools, machine tools and computer assisted manufacture.

3. Testing

This requires techniques for investigating the technical performance of a design

4. Evaluating

This requires strategies for assessing the quality of a design against a range of criteria.

5. Critiquing

This requires an ethical framework for assessing the impact of designs and related technologies on society and their overall desirability.

These fundamental subject-specific operations and skills mirror those that are used by professional designers, engineers and technologists concerning the nature of their designs – the overall purpose, how they will work, what they will look like, how they will be made, all considered in the light of users needs and wants, and market opportunities. They include testing and evaluation and are extended to the wider activity of critiquing that involves making judgements as to the worth of design and technology in the light of their effects. These operations and skills are used in conjunction with the concepts and knowledge to enable action to be taken in the light of the key principles.

To some extent the above description of the facts, concepts, principles and fundamental operations that underpin the teaching and learning of design and technology has been informed by the Delphi study of the concepts and contexts in engineering and technology education (deVries, Hacker and Rossouw 2009).

Four teaching strategies

Here I will consider four broad strategies for teaching design and technology. These are:
- Making without designing,
- Designing without making,
- Designing and making
- Exploring the technology and society relationship.

Imagine an activity in which pupils working collaboratively make a small scooter using plans provided by the teacher and a set of part prepared materials and components. I am indebted to my colleague David Baker for this inspirational task (Baker 2011). Each group of pupils perhaps four in number produced a finished scooter which they can ride individually. They have the opportunity to develop skills and tricks within their group and through practice and observation identify the groups 'best scooter rider' and these 'best riders' compete against each other to be awarded class 'best scooter rider' award. Most pupils aged 11 – 12 years would thoroughly enjoy this activity and in the process acquire a wide range of making, assembly, maintenance and repair skills. Hence it is not difficult to justify this sort of activity as one that it worthwhile within a design and technology education programme. However if all the experience were of this type, making without designing, however attractive and appealing there would be significant omissions with regard to a balanced design and technology education.

Imagine an activity in which pupils design without making. This was the premise for the Young Foresight project (Young Foresight 2000) in which pupils were required to work collaboratively in designing but NOT making products and services which used new and emerging technologies. One such technology was a material called QTC which could act as a stress dependent conductor. In a relaxed state it has a very high resistance. Stressing the material causes the resistance to decrease, the greater the stress the less the resistance and the greater the conductivity. One group of pupils, aged 13 years, used this idea as the basis for an epilepsy attack alarm system. One of the pupils knew from personal experience that the onset of an attack was accompanied by rapid movements in the jaw just below the ear. The group reasoned that such movement could apply pressure to a piece of QTC, worn in a discrete earpiece, and the resultant change in conductivity could be used to trigger a system that used GPS technology to alert paramedics that an attack had happened and the location of the person experiencing the attack. This design without making activity enabled the pupils to identify a design task that they thought worthwhile, to consider the application of new technology and integrate this application into a systems view of modern communication technology. Had the pupils been required to make their ideas for using QTC it is extremely unlikely that they would have considered such a design proposal and if they had they would almost certainly have abandoned it as beyond their making capabilities and the resources available in their school.

A more recent example of designing without making is provided by the Nuffield Key Stage 3 STEM Futures Project (Nuffield Foundation 2010). This project introduces pupils to cradle to cradle thinking (Braungart & McDonough 2009) in which manufacturing is closed loop i.e. the materials and components used in the first place came from a sustainable source or waste stream from another manufacturing process and when the useful life of the product is over there are systems in place to return all the materials and components to the manufacturing system of other products. In this project pupils are challenged to work collaboratively in using skills, knowledge and understanding about closed loop systems to identify a problem or question relating to sustainable futures. They then research, design and present a closed loop solution. Hence, an intriguing overarching question could be "How can we redesign familiar household products using cradle to cradle thinking?" which could lead to considering which is more sustainable a towel or a hair drier, a vacuum cleaner or a broom, why we might choose the less sustainable option and then tackling the more specific design without make task of designing a cradle-to-cradle hair dryer or vacuum cleaner. This would be an interesting and relevant challenge and provide a means of introducing pupils to new and very important thinking about the way manufacturing industry needs to adapt if global resource depletion is not to have a serious and deleterious effect on world economies. This approach to thinking about design and technology is being actively promoted by the Ellen MacArthur Foundation. (See http://www.ellenmacarthurfoundation.org/education). However a programme that consisted solely of such exercises would not provide a balanced approach to design & technology.

Imagine an activity in which pupils design what they are going to make and then make what they have designed. This is often seen as the heartland of technology education although it does not reflect the reality of technological activity in the world outside school where those who design artefacts are usually not those who manufacture them. The decision making that pupils have to undertake when they are designing and making has been described as involving five key areas of interdependent design decision (Barlex 2004, Barlex 2007a): conceptual (overall purpose of the design, the sort of product that it will be), technical (how the design will work), aesthetic (what the design will look like), constructional (how the design will be put together) and marketing (who the design is for, where it will be used, how it will be sold). This approach can be represented visually as a pentagon diagram shown in Figure 1.

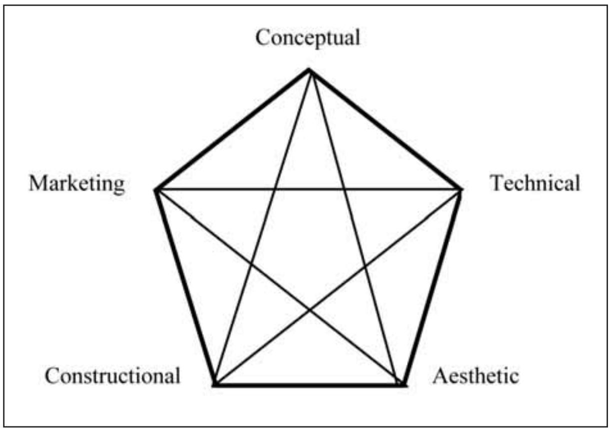

Figure 1. The design decision pentagon

This interdependence of the areas is an important feature of design decisions; hence, the lines connect each vertex of the pentagon to all the other vertices. A change of decision within one area will affect some, if not all, of design decisions that are made within the others. The teacher usually identifies the sort of product the pupils will be designing and making. Hence, it very difficult for pupils to engage in conceptual design but there are still many opportunities for making design decisions in the other areas. It is the juggling of these various decisions to arrive at a coherent design proposal that can then be realised to the point of fully working prototype that provides the act of designing and making with such intellectual rigour and educational worth and an essential part of design and technology education. It is of course necessary to ensure that the outcomes of designing and making meet criteria that establish their viability and worth. The following is offered as an initial list for further discussion.

- Embedded within them must be high learning value.
- The resources required must be such that the outcomes are affordable and the processes by which they are achieved manageable.
- It is important that they are intriguing, desirable and non trivial as far as pupils are concerned. Hence the outcomes should have utility whatever the focus area of learning.
- To relate this designing and making to the world outside school it will be important for pupils to consider life cycle analysis of similar manufactured items.

To relate this designing and making to the way technology develops through the exploitation of phenomena (Arthur 2009) it will be useful to consider this as a starting point for developing some designing and making activities as has been carried out by Phillip Holton in his unit of work on the Peltier effect (Design and Technology Association 2011). In response to the extent to which embedded intelligence is becoming a part of many devices in common use this should be a feature of some of the outcomes designed and made by pupils.

It is possible that pupils can as part of a design and technology course of instruction carry out making without designing, designing without making and designing and making and not have the explicit opportunity to explore the relationship between technology and society and through this develop an understanding of the nature of technology. David Layton (Layton 1995) has argued that developing critique competence in young people with regard to technology is a very important facet of technology education. Arthur (2009) describes our relationship with technology as being almost bipolar in terms of our trust for the natural compared to our suspicion of the artificial.

These two views, that technology is a thing directing our lives, and simultaneously a thing blessedly serving our lives are simultaneously valid. But together they cause unease, an ongoing tension, that plays out in our attitudes to technology and in the politics that surrounds it (page 214).

…we trust nature, not technology. And yet we look to technology to take care of our future – we hope in technology. So we hope in something we do not quite trust (page 215).

A school design and technology programme that did not engage pupils with exploring our ambivalent relationship with technology would seem to be missing an essential ingredient.

Thinking about transport provides interesting opportunities for exploring the relationship between technology and society. The government agency Foresight produced a report on the role of intelligent infrastructure for the future of transport (Foresight 2006)) and this has been used to inform the development of curriculum unit change of place (Barlex, 2007b) that requires pupils to consider the limitations of current transport systems and design alternatives that take into account the development of intelligent infrastructure. This activity would certainly involve an exploration of the relationship between technology and society. It is important to find opportunities for using pupils' practical interests as a starting point for exploring the technology and society relationship. Many pupils are interested in slot car racing and recent professional development in this area has enabled pupils to design and manufacture their own body shells using 3D printing (Brotherhood 2011). It should be possible to capitalize on this interest by asking pupils to find out if they can run their slot cars on solar energy and then ask them to consider if it would be possible to develop on electric road system powered by solar energy. The immediate response from many pupils would surely be “Don’t be daft, Miss!” but visiting the solar roadways website (Brusaw 2011) would soon reveal that this is a definite possibility. Scott Bursaw and his wife Julie, who are based in Idaho, USA, have developed the idea of a Solar Roadway that is a series of structurally engineered solar panels that are driven upon. The idea is to replace all current petroleum-based asphalt roads, parking lots, and driveways with Solar Road Panels that collect energy to be used by homes and businesses. The ultimate goal is to be able to store excess energy in or alongside the Solar Roadways. This renewable energy replaces the need for the current fossil fuels used for the generation of electricity. This, in turn, Scott estimates would cut greenhouse gas emission literally in half. At the time of writing this project has just been awarded a $750,000 grant for further development by the Federal Highways Commission.

Hence any ‘grand plan’ for a design and technology curriculum will need to give each of these four activities appropriate significance. Depending on the overall purpose of any one such curriculum the relative significance of these components may vary but it would seems that each should be present to some degree. It will be up to teachers in schools to decide the balance that will be most appropriate for their pupils and of course it will be possible to give different significance to the contributing activities for different courses operating in the same school.

An irresistible and transformative curriculum

At this time when the future of design and technology is in questions it is essential that the learning experience is irresistible to pupils and through the experience they are transformed into young people with values and competences that will enable them to make a positive and effective contribution to society. Such a curriculum will lead to demand from pupils, parents, and prospective employers for the subject to be an essential component of the curriculum. In this section I identify and discuss several key elements that need to be considered in devising such a curriculum.

Supporting creativity

The act of designing is by its very nature creative but enabling this creativity through design activities requires a careful balance of challenge and skill. Mihály Csíkszentmihályi in his seminal work Flow: The Psychology of Happiness (1992) explored this and his thinking is summarized in Figure 2. People who are in a state of flow experience intense concentration and enjoyment coupled with peak performance. The kinds of activities that can bring us into this state involve a challenge, but a challenge that is balanced by the availability of existing skills that enable us to respond confidently to that challenge. If the challenge is high but the skill level low the result is anxiety. If the skill level is high but the challenge low then the result is boredom. As teachers managing learning in which designing is central if we want our pupils to be creative and experience ‘flow’ then we need to ensure an appropriate challenge skill balance.

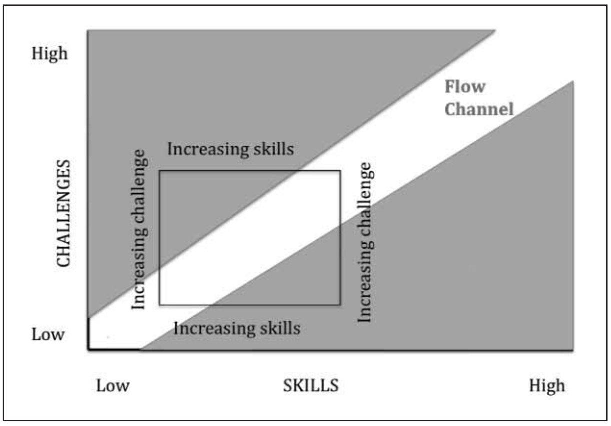

Figure 2. The balance between challenge and skill taken from Flow (1992)

Revealing the power of design

An important aspect of designing is that the designer should take into account who the proposed design is for. Bill Nicholl (Nicholl et al 2011) has been critical of the situation in many schools where those who will use a design are not considered by the pupils who are designing. Allan Chochinov in his introduction to Emilly Pilloton’s book Design Revolution (2009) asks the question “Is there a distinction between ‘good design’ and ‘design for good’?” The long list of products that are changing people’s lives that form the core of Emily’s book leaves no doubt that it is certainly possible to ‘design for good’. However much design does not fall into this category. Philippe Starke (Die Zeit 2008) one of the most well known designers is quoted as saying, “Everything that I designed is absolutely unnecessary”. Critics of such design for design’s sake have characterised such activity as “The arms race of designer toilet brushes” (Pink 2006). In the design based tasks we ask young people to undertake it is essential that at least some the outcomes, whether they are design ideas or realised artefacts, have significant worth and meet the needs of intended users. The book ‘Design like you give a damn’ (Architecture for Humanity 2006) provides a wide range of inspirational case studies of the power of design to be design for good. I think it is important to expose our pupils to such work and if at all possible to engage them with some community based design activities in which they can see that their design activities can make a difference and be 'design for good'.

Supporting personal effectiveness
In developing self-efficacy in young people it is important that they have some control over what they learn and how they learn. This is not necessarily easy to achieve. In the Nuffield Key Stage 3 STEM project this was discussed in terms of the extent to which pupils had choice of the topic they were going to address compared with the extent to which they were autonomous as opposed to directed in the way they responded to the topic. This is described in Figure 3.

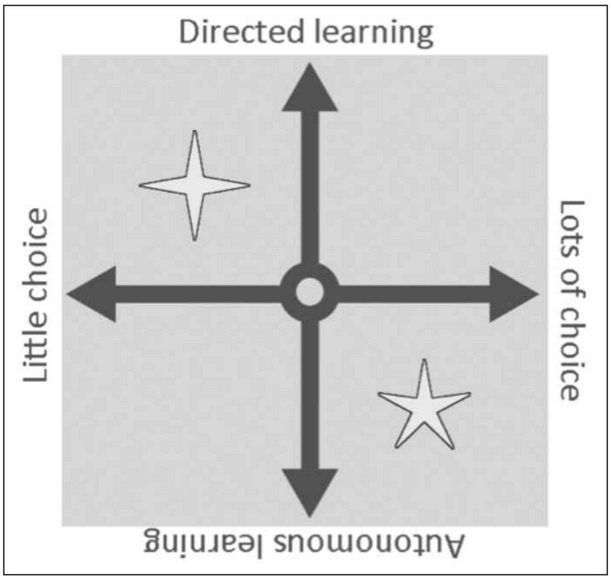

Figure 3. The 'autonomy cross' taken from the Nuffield STEM Futures Project

When pupils are required to address a topic it is possible for the teacher to decide on the topic and direct the learning by which the topic will be studied – the situation in the top left quadrant. The pupils have little if any choice and no autonomy. In situations where there are particular syllabus requirements to be met and pupils have little previous experience of deciding how to approach a topic this may be a defendable position and without doubt some useful learning would take place. The opposite position is in the bottom right quadrant where pupils not only choose the topic but also the way they will respond. The pupils have lots of choice and autonomy. If this situation is successful it is more likely to develop self-efficacy than the one previously described.

The Design and Technology Association has devised an approach which teachers can use to help pupils move towards the bottom right quadrant. The Association's Digital Design and Technology initiative has developed a starting points approach to engage pupils with the designing and making of electronic products. The starting points were chosen on the grounds that they could lead to pupils designing and making electronic products of varying complexity depending on the sophistication with which the pupils responded. Hence the starting points are not age or key stage specific. The six starting points identified were: playtime, keeping in touch, keeping secure, staying safe, thinking machines and other worlds There are of course many other possible and valid starting points but for the purposes of this exercise this number was felt to be sufficient and provided across the set a sufficient variety to be of interest and use to both teachers and pupils.

On the Project website (www.ectcurriculum.org/) the starting points are presented as visual brainstorms allowing the teacher and the class to explore the context for a wide range of possible briefs. These open starting points provide the opportunity to give pupils a voice as to what sort of product they want to design and make. The exact nature of the products designed and made will depend on the age and previous experience of the pupils and the resources available in the school but giving the pupils such choice will provide ownership and is likely to increase their motivation. As pupils become used to such an approach it is possible that not only will they be able to make choices as to the nature of the product they design and make but also have some autonomy in the way they go about this process.

Expectations and collaboration
David Layton was a tremendously powerful advocate for design and technology in the school curriculum. His work on the interim report (Department for Education and Science and the Welsh Office 1988) indicates clearly his appreciation of the unique contribution the subject can make to the education of young people. However he did warn against expecting too much (Layton, 1995).
It would be sad if an exciting and radical curriculum innovation, potentially of great significance, should collapse under the weight of the unrealistic responsibilities being placed upon it. (page 115)

Hence, it is important that as we champion design and technology in the curriculum we take heed of David's warning. False rhetoric that makes promises, which the subject cannot deliver in practice, will severely damage the subject's credibility. There is no place for spin in the way we promote design and technology. It is easy to adopt a naïve Darwinian position with regard to design & technology in the curriculum and see it as in direct competition with other subjects for time on the timetable and resources at a time of scarcity. Janine Benyus (1997), an advocate of biomimicry as an intelligent way forward in tackling many of the challenges which face us, paints a sophisticated picture of the natural world in which diversity thrives through cooperation. She describes how all the plants in a meadow grow in harmony without any outside intervention in a way that is collaborative, restorative and synergic, with each plant reinforcing others' contributions. I wonder if a meadow can be an analogy for the community that is a school? Pursuing this analogy we would see the subjects in the school curriculum working together to provide an environment in which young people can flourish. At a time when the English Baccalaureate appears to threaten the very existence of design and technology this may seem a hopelessly idealistic view. But I think idealism at such times is important. There is some hope that 'E Bacc' as it is known may not hold sway; a Commons Select Committee on Education has delivered an adverse report (Education Committee Fifth Report 2011) and indicated that it should be rethought. And I am always reminded of the position taken by Vera John-Steiner who has written persuasively about creative collaboration. At this time I believe that we need both creativity and collaboration to develop a design and technology curriculum that is fit for purpose in the ways described above. Vera argues that "dignified interdependence gives achievements far beyond individual, isolated capacities" (John-Steiner 2000). Hence I believe that we should, quite consciously, go about the business of forming alliances both within design and technology and between design and technology and other school subjects in which there is dignified interdependence so that the whole is much greater than the sum of the parts.

In conclusion

Success in GCSE and GCE examinations is a key measure for school accountability and the placing of schools in performance league tables. This "examination rules" view of education is taken to extreme by the awful Professor Umbridge in J K Rowling's Harry Potter and the Order of the Phoenix (2003) illustrated in her conversation with Harry about the purpose of education.

Professor Umbridge: *It is the view of the Ministry that a theoretical knowledge will be more than sufficient to get you through your examination, which after all, is what school is all about.*

Harry Potter: *And what good's theory going to be in the real world?*

Professor Umbridge: *This is school, Mr. Potter, not the real world.* (page 219/220)

Few school subjects accept the 'theory at expense of practice' advocated by Professor Umbridge but one of design and technology's unique features is that whilst it acknowledges that the acquisition of knowledge, understanding and skill is necessary this is not sufficient. The prime function of this subject is to enable pupils to take action in ways they are relevant to their future lives whatever their career path in the world outside school.

Richard Kimbell and David Perry (2000) captured this unique characteristic of design and technology as follows.

The real products of design and technology are empowered youngsters, capable of taking projects from inception to delivery; creatively intervening to improve the made world; entrepreneurally managing their resources; capably integrating knowledge across multiple domains; sensitively optimising the values of those concerned; and confidently working alone or in a team (page 19).

At this time of potential difficulty for design and technology in the school curriculum it is important that we hold true to this vision and ensure that the curriculum the community of practice develops in response to the forthcoming review reflects this vision.

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