Re-Building
Design &
Technology
In the secondary school
curriculum | Version 2

A Working Paper

David Barlex
Torben Steeg
Re-Building Design & Technology
In the secondary school curriculum

Authors
David Barlex
Torben Steeg

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Contributors

David Barlex
David is an acknowledged leader in design & technology education, curriculum design and curriculum materials development. He taught in comprehensive schools for 15 years achieving head of faculty positions in science and design & technology before taking university positions in teacher education. He directed the Nuffield Design & Technology Project and was Educational Manager for Young Foresight. David is well known for his interest and expertise in developing curriculum materials that support pupil learning from a constructivist perspective. He uses this approach to develop young peoples’ ability to understand and critique the design decisions made by professional designers and those they make themselves in design & technology lessons. This informed the Nuffield Design & Technology publications which have been widely used in the UK and emulated abroad – Russia, Sweden, Canada, South Africa, Australia, New Zealand.

Torben Steeg
Torben is a freelance consultant in education, with research and curriculum development interests that include the interactions between D&T, Computing, ICT, Science, Mathematics and Engineering and, within D&T, programmable systems, systems thinking, electronics and communications technologies, novel technologies, disruptive technologies and the implications of the maker and hacker movements for education. He is a member of the editorial board for the D&TA’s ‘D&T Education; An International Journal’, a founder editor of the on-line journal ‘ECT Education’ and a Fellow of the RSA. He has provided advice, curriculum development and CPD activity to a wide range of organisations and is the author of a range of general and academic publications. He is an active participant in Manchester’s maker community and since 2012 has been an organiser of the Manchester Maker Faire/MakeFest.

Nick Givens
Nick is a Senior Lecturer in Education at the University of Exeter Graduate School of Education. He taught in several comprehensive schools- becoming head of design & technology - and subsequently established a design & technology department from scratch in a Sixth Form College. Since moving into university-based initial teacher education, he has taught undergraduate and postgraduate design & technology trainee teachers, led an undergraduate teacher education programme and a postgraduate design & technology teacher education course. He has also been an author and a field officer for the Nuffield Design & Technology Project. His research interests include curriculum development in design & technology, inclusivity within education and, most recently, approaches to teaching about ‘disruptive’ technologies.
Introduction

This paper has been written to inform all those who are concerned about the status and nature of design & technology in the secondary school curriculum. It has been developed in response to the serious and continuing decline in the uptake of GCSE design & technology since the subject was introduced into the National Curriculum in 1989. At that time, some 95% of young people studied the subject to the age of 16+. Since then this has fallen to about 28% (Mitchell, 2016) and, with the removal of food from design & technology specifications, it is predicted to fall much further.

Rather than identify the many and varied reasons why such a decline has taken place, we develop the substance of four features of the school subject design & technology which we believe are essential if the subject is to reverse its decline and start, once again, to make a significant contribution to the education of the majority of young people.

These features are:
1. Sound epistemology
2. Clarity of purpose
3. Good practice
4. Informed stakeholders

The paper continues by exploring how each of these can be achieved:
5. Achieving sound epistemology
6. Achieving clarity of purpose
7. Achieving good practice
8. Achieving informed stakeholders

The task of rebuilding design & technology is one that will require the whole design & technology community to pull together in the same direction. The first purpose of this paper is to map out the right direction. The second purpose is to suggest ways in which the community might work together to move in that direction. Hence the paper makes a series of recommendations to key stakeholders in the hope that by responding to these recommendations the prospects for design & technology in the secondary school will improve considerably, both in the short and medium terms. Inevitably, many of our recommendations are to the D&T Association as a key and leading organisation within our community. We wouldn’t want to give the impression, however, that we think the task is theirs alone; rebuilding is a daunting task that will require all of us to work together alongside the Association. We are aware that taking some of these recommendations forward will require external funding, so where appropriate we have worded the recommendations with this in mind.
We want to be clear that we have deliberately focused on re-building and not a radical revision of the subject. This is because we believe the original vision for the subject, as laid down by the Parkes Report (Department of Education and Science /Welsh Office, 1988), is still compelling.

A point of definition that requires immediate comment concerns the use of the dual term design and technology. Our understanding is that whereas most, but not all, design activities will generally include technology and most technology activities will include design, there is not always total correspondence. Our use of design and technology as a unitary concept, to be spoken in one breath as it were, does not therefore embody redundancy. It is intended to emphasise the intimate connection between the two activities as well as to imply a concept which is broader than either design or technology individually and the whole of which we believe is educationally important. (p. 47)

In our minds, the Report represents both the unique nature of the subject and the reasons for teaching it extremely well. The difficulty the subject has faced is, we think, that it has not always been able to meet these expectations, for reasons that we explore in this paper.

It is also worth noting that only recently has the whole curriculum from 5-18 been revised; we doubt there is appetite, either amongst teachers or the relevant national bodies, to carry out further significant reform at present. Rather we think that the revised expectations we have identified provide a strong foundation for the re-building we are arguing for. Hence, we believe that a radical revision, if attempted, is almost certain to fail and that re-building is by far the much better option. This does not mean that within this re-building young people should not be engaged with modern technologies for design and manufacture nor that they should not be engaged in designing and making technically sophisticated products; quite the reverse. Modernisation is essential and this can be achieved within a re-building strategy.

This is v2 of Re-Building Design & Technology. It has been informed by the responses we have had to the first version. We have taken many of these responses into account in rewriting the original eight sections and have introduced a completely new section “Re-building – necessary but not sufficient”.

Modernisation is essential and this can be achieved within a re-building strategy
1 Sound epistemology

Epistemology is the study of knowledge; what we know, how we know it, and what it means to know something. Subject disciplines, both at school and ‘higher’ levels, are largely defined by a combination of the scope of knowledge they deal with and how that knowledge is established. Thus, to talk about design & technology as a subject means we need to be clear about the nature of knowledge in the subject.

Design & technology is rightly concerned with procedural knowledge (knowing how). But a neglect of the underlying conceptual knowledge (knowing that) has led to the subject being perceived as having less worth than other subjects in the curriculum and concerned only with skills. It is important to address this misconception. One way to do this is to clearly define ideas about design & technology (ideas that describe design & technology’s fundamental nature) and ideas of design & technology (ideas that form the conceptual knowledge underpinning the subject).

We think of these as the Big Ideas in design & technology, and they are summarised in Figure 1 on page 7.

Ideas about design & technology (its fundamental nature) might include:

<table>
<thead>
<tr>
<th>Ideas about design &amp; technology (its fundamental nature)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through design &amp; technology people develop technologies</td>
</tr>
<tr>
<td>and products to intervene in the natural and made worlds</td>
</tr>
<tr>
<td>Design &amp; technology uses knowledge, skill and understanding from itself and a wide range of other sources, especially but not exclusively science and mathematics</td>
</tr>
<tr>
<td>There are always many possible and valid solutions to technological and product development challenges, some of which will meet these challenges better than others</td>
</tr>
<tr>
<td>The worth of technologies and products developed by people is a matter of judgement</td>
</tr>
<tr>
<td>Technologies and products always have unintended consequences beyond intended benefit which cannot be fully predicted by those who develop them</td>
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</tbody>
</table>

Table 1
Ideas about design & technology describe design & technology’s fundamental nature
Ideas of design & technology (its conceptual knowledge) might include:

<table>
<thead>
<tr>
<th>Knowledge of materials</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Properties</td>
</tr>
<tr>
<td></td>
<td>Footprint</td>
</tr>
<tr>
<td></td>
<td>Longevity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge of manufacturing</th>
<th>By subtraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>By addition</td>
</tr>
<tr>
<td></td>
<td>By forming</td>
</tr>
<tr>
<td></td>
<td>With finishing</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge of functionality</th>
<th>Powering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controlling</td>
</tr>
<tr>
<td></td>
<td>Structuring</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge of design</th>
<th>Identifying peoples’ needs and wants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Identifying market opportunities</td>
</tr>
<tr>
<td></td>
<td>Generating, developing and</td>
</tr>
<tr>
<td></td>
<td>communicating design ideas</td>
</tr>
<tr>
<td></td>
<td>Evaluating design ideas</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge of critique regarding impact</th>
<th>For justice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>For stewardship</td>
</tr>
</tbody>
</table>

Our view is that “know how” uninformed by “know that” is not an appropriate epistemology for the subject. We believe it is incumbent upon us to identify and agree on a core body of knowledge, the learning and understanding of which enables young people to respond effectively through procedural knowledge to meeting the challenges of designing and making items of worth.

This is what we are trying to do by identifying and clarifying the Big Ideas for the subject. We hope that for most readers there is little to surprise here; what we have outlined reflects both recent and current national curriculum and GCSE subject content for design & technology.

The description of an epistemology for design & technology based on Big Ideas of and about the subject given here is of necessity at a high level of summary and lacking specifics. A more detailed description including some justification for its features is available as Appendix 1.
Figure 1
Big Ideas for design & technology

Intervention
Maths & science
No single right answer
Worth debatable
Unintended consequences

Addition
Subtraction
Forming
Assembly
Finishing

Properties
Sources
Footprint
Longevity

For justice
For stewardship

Needs and wants
Market opportunities
Generating developing and communicating ideas
Evaluating

D&T

Fundamental nature
Manufacture
Critique
Functionality
Design
2 Clarity of purpose

Having established the knowledge base for design & technology as a series of Big Ideas, we now turn to the question of why it is important for this subject to be a part of the educational experience of all young people.

We can envisage the school curriculum as learning composed of a jigsaw of different subjects where each subject makes a significant and unique contribution to that learning.

To become a rounded and successful member of society a young person will need learning from each of the pieces. If learning from any piece is marginalised or missing, then the young person will not have been given a fully rounded education and will be at a disadvantage.

Note that this ‘jigsaw of subject pieces’ model for the curriculum need not be static. The individual pieces may change position and join with other pieces in response to particular teaching and learning intentions.

For example, the pieces for science, mathematics and design & technology may become joined in response to STEM leading to, for example, a consideration of bioluminescence as an alternative to LEDs.

Or design & technology might join with geography and science in response to a consideration of climate change issues to formulate an idea for a local community to reduce its carbon footprint.

Or design & technology might join with history in teaching about the impact of technology on society to explore how lessons from the past might be employed in resolving current-day issues.

Hence the jigsaw piece model goes some way to mitigating the problem of subject silos.

If each subject is a piece in the jigsaw that overall provides a rounded education, what then governs the status of any single subject?
The contribution of mathematics, English and science to a young person’s overall education is simply not contested. History, geography, and second languages have established themselves as highly desirable and there is significant encouragement by head teachers and parents for pupils to study such subjects to the age of 16 years. Taken together these six subjects have been compiled by the government into a suite of subjects, designated as the EBacc. The government’s purpose is to provide information to parents, and others, about the achievements of pupils in a core set of academic subjects which are believed to enhance the chances of progressing on to further study.

To meet EBacc criteria, a pupil must have obtained a grade A* to C in English, maths, two sciences, history or geography (referred to as humanities), and an ancient or modern foreign language.

To be taken seriously by those concerned with young people’s education, a subject outside the EBacc must be very clear about the contribution it makes to their learning, particularly regarding its uniqueness (i.e., the learning is not provided by any of the other jigsaw pieces) and its rigour (both practical and intellectual). This is the challenge facing design & technology.

It is important, therefore to clarify and understand the possible arguments for teaching design & technology. Following the terms used by the Expert Panel (Department for Education, 2011, p. 15), we present next four of these arguments which, it is important to note, are not mutually exclusive.

**Four arguments to support design & technology in the curriculum**

**An economic argument**
A steady supply of people who have studied design & technology is essential to maintain and develop the kind of society we value. Design & technology is central to the innovation on which our future economic success as a nation depends. For those young people who achieve a design & technology qualification at school the experience may well predispose some of them to consider a technical career. This is important as our country faces a “STEM skills” gap (Institute of Engineering and Technology, 2016).
A personal argument
The learning achieved through studying design & technology at school is useful in everyday situations, as it enables young people to deploy design skills and technical problem solving to address and solve practical problems at both the personal and community levels.

A social argument
In their communities, their workplaces, and through the media, people encounter questions and disputes that have matters of design and/or technology at their core. Often these matters are contentious. Significant understanding of design and of technology is needed to reach an informed view on such matters and engage in discussion and debate.

A cultural argument
Technologies and the design thinking behind them are major achievements of our culture. Everyone should be helped to appreciate these, in much the same way that we teach pupils to appreciate literature, art and music.

Exploring these arguments
The economic argument is difficult to justify as a rationale for teaching design & technology to all young people, as the total of professional engineers, technologists and designers is only a few per cent of the whole population of an industrialised country. Employers might argue, however, that unless a high percentage of the school population is exposed to design & technology then not all of those who might be inclined to take up careers in this area will be reached. Nevertheless, the foremost goal of a general design & technology education cannot be to train the minority who will actually “do” technology as a career.

The personal argument can be extended to a consideration of the personal qualities developed by being able to deploy design and technical problem solving skills. The creative activities of designing and making, which are a major part of design & technology courses, not only give immense personal satisfaction but, importantly, develop a sense of self-efficacy which provides young people with a positive self-image about their ability to be successful. We have no doubt that these are important elements of a rounded education, and ones that design & technology is uniquely able to provide. Yet we don’t believe they are sufficient to justify the subject’s place in the curriculum. The expert panel for the 2011 Curriculum Review took a similar view arguing that design & technology did not have; “sufficient disciplinary coherence to be stated as (a) discrete and separate National Curriculum ‘subject’” (Department for Education, 2011, p24).
Fortunately, other views prevailed and design & technology was retained as a National Curriculum subject at that time; we cannot be optimistic that any future curriculum review would have the same outcome.

The role of education to produce informed citizens able to take an active role at various ‘levels’ in their community and able to engage in informed and rationale debate lies at the heart of the social justification for the subject. There seems little doubt that the pace of technological development is accelerating. Some argue that it is doing so at an exponential rate (Kurzweil, 2005). While new technologies have always created a degree of concern in certain elements of society, it is noteworthy that some of the worries being expressed about imminently widespread new technologies are coming from within the technology community itself (e.g., Achenbach, 2016). Even if one takes a reasonably sanguine view, many of these new and emerging technologies are likely to have significant impact on society, almost certainly being disruptive (Barlex, Givens & Steeg, 2015) to many current practices in people’s personal, social and working lives. There is clearly a need for an informed public discourse about the development and deployment of such technologies. This is the nub of the social argument: Enabling the public to contribute significantly and intelligently to such discourse.

The cultural argument forces us to ask, “What are the grand narratives of design & technology?” There have been moments in time when the outcomes of design & technological doing and thinking have had a profound effect on human history. For example, early in this narrative the development of cooking, the invention and development of simple tools from flint and bone, the ability to refine ores to produce metal, the ability to grow and farm crops and livestock, the production of shelters, and the development of clothing made huge differences to the quality of human life. Basic needs could be met more easily, leaving time and energy available to develop cultural identity through a wide range of creative and commercial activities. Subsequently there has been a succession of technological “revolutions”, the industrial revolution and the information revolution being among the most recent. These have all been enabled by humanity’s ability to envisage what might be and take action to realise these as yet unreached visions. So, any grand narratives of design & technology must consider imagination and intervention. Such imagining must of course be grounded in the realities of the physical universe; more and

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1 Information on our Disruptive Technologies Project is available at: https://dandfordandt.wordpress.com/projects/disruptive-technologies/
more the scientific understanding of the phenomena that constitute the physical universe underpin the interventions that result from the imagination. The variety and impact of the interventions are key components of the grand narratives. The interventions stemming from an imagined but not yet realised future reality might take many forms, with different degrees of success. And inevitably any intervention will have unintended consequences beyond its intended benefit. The story of humanity’s interventions, their variety and consequences both intentional and accidental provide the grand narratives of design & technology. And they reveal the nature of the Big Ideas underpinning the subject:

- Intervention in the natural and made worlds
- How this intervention uses knowledge, skill and understanding from a wide range of sources, especially but not exclusively science and mathematics
- That there are always many possible and valid solutions to technological and product development challenges, some of which will meet these challenges better than others
- The worth of technologies and products developed by people is a matter of judgement
- That technologies and products always have unintended consequences beyond intended benefit which cannot be fully predicted by those who develop them

These narratives can be explored through the history of specific technologies, through the lives of individual designers, engineers, architects, through the development of different civilisations, through investigating products as well as through the designing and making that children engage in.

We believe that each of these four arguments should inform a school design & technology curriculum. While an individual school’s circumstances may vary the relative significance of the arguments, to produce a curriculum that did not respond in part to each of them would be a curriculum that was lacking an important dimension. It seems to be the case, however, that too often the current justification for design & technology rests on the economic and personal arguments. As the above discussion makes clear, we have taken a strong view that these are not sufficient and, indeed, that relying on these two only puts the future of the subject at risk. By the same token, the cultural and social justifications seem underdeveloped in rationales for the subject. Significant effort needs to be made in developing these in ways that teachers can realistically use right from the start of the design & technology learning journey in KS1.
We further believe that meeting the totality of these arguments will be achieved by teaching children to achieve a combination of technological capability and technological perspective. We define these as follows:

**Technological capability** is designer-maker capability, capturing the essence of technological activity as intervention in the made and natural worlds.

**Technological perspective** provides insight into "how technology works" which informs a constructively critical view of technology, avoids alienation from our technologically-based society and enables consideration of how technology might be used to provide products and systems that help create the sort of society in which pupils wish to live.

Finally, we note that to develop the cultural and social arguments within the design & technology curriculum is no small task. But, if we are right, then it is a task that cannot be left undone and the design & technology community will need to find the means within itself to undertake it.

So, having established what we believe is a sound knowledge base for the subject along with a suite of reasons for including it in the curriculum, we turn to discussion of how best we might teach design & technology to achieve the breadth of learning that is required.
3 Good practice

The following sentences, derived from the writings of Jacob Bronowski in his seminal work, The Ascent of Man (1973), provide a powerful justification for teaching the subject that touches on all four of the arguments noted in the previous section (economic, personal, social, cultural).

*Envisaging what might exist in the future and using tools and materials to create and critique that future is a unique human ability, which has led to the development of successive civilisations across history. It embodies some of the best of what it means to be human.*

*Through teaching young people design & technology schools introduce pupils to this field of human endeavour and empower them to become people who see the world as a place of opportunity where they and others can, through their own thoughts and actions, improve their situation.*

The underlined words and phrases in the justification have considerable implications for the subject as shown in Table 3, below.

<table>
<thead>
<tr>
<th>Word or phrase</th>
<th>Implications for the subject The subject will ...</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Envisaging what might exist in the future</td>
<td>... require students to be imaginative</td>
<td>E, S, C</td>
</tr>
<tr>
<td>tools and materials</td>
<td>... require students to develop practical skills</td>
<td>E, P, S</td>
</tr>
<tr>
<td>create</td>
<td>... require students to be imaginative</td>
<td>E, P, S, C</td>
</tr>
<tr>
<td>critique</td>
<td>... require students to be thoughtful and develop intellectual skills</td>
<td>E, P, S, C</td>
</tr>
<tr>
<td>unique human ability</td>
<td>... require students to understand the ways that design &amp; technology underpins cultural and social structures</td>
<td>E, S, C</td>
</tr>
<tr>
<td>empower</td>
<td>... develop students’ self-efficacy</td>
<td>E, P</td>
</tr>
<tr>
<td>see the world as a place of opportunity</td>
<td>... develop in students a positive attitude toward confronting difficulties and problems</td>
<td>E, P, S</td>
</tr>
<tr>
<td>own thoughts and actions</td>
<td>... require students to be both reflective and active</td>
<td>E, P, S</td>
</tr>
<tr>
<td>improve their situation</td>
<td>... require students to make judgments as to what is worth doing</td>
<td>E, P, S</td>
</tr>
</tbody>
</table>

*Table 3
Implications for the subject*
These implications, in turn, inform the activities that can be used to build an appropriate set of pedagogies for the subject.

Four broad activities are generally recognised as being required to make up an appropriate pedagogy:
1. designing and making,
2. making without designing,
3. designing without making
4. considering consequences

Designing and making
This is often seen as the heartland of design & 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 need to undertake when they are designing and making has been described as involving five key areas of interdependent design decision (Barlex, 2007), shown diagrammatically in Figure 3:

- **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)
- **Marketing** (who the design is for, where it will be used, how it will be sold).

![Figure 3](image-url)
The interdependence of these areas is an important feature of making design decisions, as change of decision within one area will affect some if not all of design decisions that are made within the others. 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 intellectual rigour and educational worth and makes it an essential part of technology education.

The Nuffield Design & Technology Project\(^2\) coined the term “Capability Task” for designing and making assignments. Through attempting such tasks young people develop and reveal their technological capability. The Project was very clear as to the need for this activity to be underpinned by two broad areas of knowledge: knowledge of the problem and knowledge for the solution.

Knowledge of the problem
Knowledge of the problem is always specific to the problem being addressed and needs to be found by exploring the situation in which the problem is embedded. It cannot be “looked up” in a general design & technology reference text. Because the scope of this knowledge can’t be predicted (and thus taught) in advance of exploring the design context, some have described the acquisition of this kind of knowledge “Just-in-Time” learning” (Gershenfeld, 2005).

A good example of the power of “Just-in-Time” learning arises when pupils are engaged with a designing and making task for young children. They realise that to understand the specific needs and wants of the children they are designing for they need to know more about, for example, the particular reading abilities of these children which might be different to their age expected reading ability. Pupils can be taught general strategies for observing situations and identifying the needs and wants of people in those situations. But the pupils have to build on those strategies for themselves when learning about pertinent aspects of a particular context – just in time to help them understand the nature of the design decisions they will need to make. And, of course, this is an iterative process, with pupils revisiting the situation as they use strategies to find out more about the requirements their design proposals must meet.

\(^2\) The Nuffield Project’s KS3 and KS4 materials are freely available from: https://dandfordandt.wordpress.com/resources/
Knowledge for the solution
Knowledge for the solution can be more easily recognised and acquired than knowledge of the problem in that, for any domain of design & technology, the knowledge does not change as the design task changes. Gears, for example, behave in the same way, in terms of principles, whether they are used in a child’s toy, a lawn mower or a motor car, although the detailed arrangement and robustness of the gearing system developed to operate in these artefacts will be different.

To ensure that students had the practical and intellectual resources with which to be capable, the Nuffield Project devised a wide range of “Resource Tasks” which could be used to teach (a) design strategies, (b) technical knowledge and understanding, and (c) making skills. It is the learning through Resource Tasks that enables young people to make sound design decisions. One might describe some Resource Task learning as “Just-in-Case” learning; learning that is likely, but not inevitably, to be useful in the future. A pupil might choose not to use what they have learned about, for example mechanisms, by avoiding mechanical solutions altogether. However, one important aspect of Just in Case learning relating to knowledge for the solution is that it can enable Just-in-Time learning. If a pupil knows nothing or very little about a particular area of knowledge and realizes that some knowledge about this might be useful for a solution to a design problem then it is a very steep just-in-time learning curve. If, however, the pupil knows something about the area, through some just-in-case learning, extending this knowledge just-in-time becomes much more feasible. Ian Leslie’s main argument in Curious (2014) is particularly pertinent: the more you already know the easier it will be to find out about what you don’t know and need to know. The Resources Tasks are also designed to support individual Just-in-Time learning; an individual can use appropriate tasks to develop knowledge as it is required.

Making without designing
Making without designing also has a place in the pedagogy. Imagine an activity in which Year 7 pupils make (and then fly) a kite. The teacher has provided the plans for the kite and, if followed faithfully, they are known to produce a kite that flies well. What might a pupil learn from making a simple kite? They would certainly learn making skills involving textiles and resistant materials. Given the nature of kites there is the possibility of teaching about forces in structures as well as key aspects of health and safety e.g. not flying near electricity pylons, avoiding cuts from taut string and preventing being pulled over.
If pupils are given a choice of materials, there is the possibility of carrying out investigations into their properties and using the results to decide on which materials to use – both for the fabric and the frame. So, this making without designing activity is very rich in learning Big Ideas (conceptual knowledge) of design & technology. Additionally, acquiring making skills is almost certainly highly enjoyable for the pupils.

**Designing without making**

Designing without making is an approach developed extensively by the Young Foresight project as the means to improve the ability to communicate design ideas, cultivate creativity and enable collaboration in design & technology lessons. Independent evaluations (Murphy, 2013) of designing without making have shown that young people do not necessarily require “something to take home”. Pupils respond enthusiastically to working collaboratively to develop design ideas providing they know at the outset that they would not be going to make their designs. In fact, this “not requiring to make” was welcomed by the pupils, as it released them from the constraints of the materials and equipment available in their school workshops.

An important feature of this approach is that pupils themselves decide on the need or want they will address and make conceptual design decisions accordingly, which provides ownership and motivation. The pupils do, however, have to justify their ideas in terms of feasibility, meeting needs and wants, acceptability to society and marketability.

**Considering consequences**

The opportunity for pupils to consider the consequences of a technology and its impact on society in general and their lives in particular is an important element of design & technology. Critique is one of the Big Ideas that underpin the subject. It is through learning to critique that young people will be enabled to partake in and contribute to on-going debates about what we do with the technology at our disposal.

A simple “winners and losers” analysis, to identify the impact of a product or technology on those who it might affect, is a very powerful way of engaging young people in considering consequences. Identification of “winners and losers” features in both the Nuffield Design & Technology Project and Young Foresight.

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3 The Young Foresight materials are freely available from https://dandfordandt.wordpress.com/resources/young-foresight/
Any ‘grand plan’ for a design & technology curriculum will need to give each of these four activities appropriate significance. Each should be present to some degree within each year.

We note that it is fairly straightforward to assess each of these four types of activity, providing the teacher is clear about the learning intentions underpinning the activity. In summary, any “grand plan” for a design & technology curriculum will need to give each of these four activities appropriate significance. Depending on the age and stage of the pupils’ design & technology experience the relative significance of these components may vary within each year of the course. But there is a strong case that each should be present, to some degree, within each year.

While we have emphasised the learning value of these four approaches to teaching design & technology others have pointed to pupils’ huge enjoyment of the practical activity of making and suggested that it is this alone which earns the subject its place in the curriculum. While we agree that making is a very important aspect of the subject, we are adamant that if this is seen as the sole reason for its inclusion in the curriculum then the status of the subject will remain low. This is not to deny the power of making, particularly successful making, which can increase a person’s confidence and self-belief.
4 Informed stakeholders

This paper argues that the viability of design & technology as a curriculum subject is dependent upon establishing (a) a sound knowledge base for the subject, (b) clarity about its role in the wider curriculum, and (c) an approach to quality teaching and learning. Ultimately, these three factors will only make a difference to the subject’s continuance in schools if the broad swathe of interest groups involved in developing, teaching and supporting design & technology work in concert to encourage its development in these directions.

A range of important stakeholders can be identified to include (in alphabetic order):
- Awarding and assessment organisations
- Government Departments
- Parents and pupils
- Professional Associations
- Professional Institutions
- Senior Leadership Teams (SLT) and governors
- Teachers
- Teacher Trainers and CPD providers

It is essential that the stakeholder knowledge of the subject is driven by an understanding of its clarity of purpose and sound epistemology, as established by those who lead the community of practice of design & technology education, as opposed to what the stakeholders might wish to be the purpose and nature of the subject.

Only limited research has investigated the beliefs of various stakeholders about design & technology (Hardy, 2016). Results showed that there is a wide variety of different views, most of which do not reflect sound epistemology and the clarity of purpose established earlier in this paper.

A challenge facing the design & technology community, therefore, is to engage in a significant dialogue with these stakeholders: a dialogue that respects different views but establishes a robust orthodoxy for the subject, its purpose and teaching methods.

Summary Parts 1 – 4

Only if clarity of purpose and sound epistemology are clearly established as the underpinning orthodoxy can pervasive good practice be developed in design & technology as a curriculum subject. These three features are necessary to develop the informed stakeholders required to change the status of the subject and reverse its decline.

It is essential that the stakeholder knowledge of the subject is driven by an understanding of its clarity of purpose and sound epistemology.
5 Achieving sound epistemology

Small-scale research in Australia (Williams & Lockley, 2012) indicated that science teachers relatively new to teaching had a clear and agreed grasp as to the nature of the subject they taught. This suggests that within the science teaching community there is orthodoxy about epistemology. The same research indicated that, in contrast to the science teachers, this was not the case for technology teachers. Subsequent parallel research in England revealed that in England, design & technology teachers also do not have an agreed understanding of the nature of their subject (Barlex & Steeg, 2013).

Establishing an agreed orthodoxy regarding the core of knowledge, understanding, skills and values that provide a sound foundation for the school subject design & technology is extremely important. Without this the design & technology community of practice will always be divided as to the fundamental nature of the subject. It was an awareness of this situation that led the Expert Panel (Department for Education, 2011), set up by the then Minister of Education Michael Gove, to advise that design & technology should not be included as a core subject in the National Curriculum in England. A major task for the design & technology community of practice is, therefore, to identify a design & technology subject knowledge orthodoxy that teachers, teacher trainers, and CPD providers can believe in strongly and use to underpin all the teaching, learning, teacher training and professional development that takes place. We emphasise here that it is important that this orthodoxy values both procedural and conceptual knowledge. We believe it is incumbent upon us to identify a body of knowledge the learning and understanding of which enables young people to respond effectively through procedural knowledge to meeting the challenges of designing and making items of worth. We also believe that acquiring procedural knowledge can be taught just as much as conceptual knowledge. The National Curriculum Programme of Study for design & technology and the new single title design & technology GCSE have been written with the aim of identifying this procedural and conceptual orthodoxy. There is no doubt that establishing this orthodoxy will be a challenge but it is one to which the profession must respond. We believe that the Design & Technology Association, under the direction of its new CEO, should address this task with some urgency.
We also emphasise that it will be essential not to confuse the identification of epistemological orthodoxy with agreement over the reasons why the subject should be taught, that is, its purpose within the curriculum. A pervasive orthodoxy as to what should be taught can be interpreted through pedagogy to reflect the several reasons for teaching the subject. In this way, teaching can be aligned to meeting the needs of different groups of young people without compromising the agreed orthodoxy of the subject. By taking this forward the Design & Technology Association would be showing much needed intellectual leadership at a time of significant change.

**Recommendation**

That the Design & Technology Association, along with key stakeholders in the d&t community, including those from the design and engineering industries, work together, including identifying the necessary funding, to establish and promote an agreed orthodoxy regarding the core of knowledge, understanding, skills and values that underpin school design & technology.
Achieving clarity of purpose

Several eminent figures from industry have given their support for design & technology. Not surprisingly this support is often couched in terms of an economic argument. There are two dangers here.

The first danger is that the argument about purpose is often determined on the ground in schools through an assumption that the subject is vocational and, by implication, not suitable or desirable for who have shown themselves to be academically successful. So this narrowed focus has clearly failed to encourage these schools to see the subject as an important part of general education for all young people. However, if the other arguments (personal, social and cultural) that maintain that the subject should be embraced as a part of general education for all young people are successful, then they can be shown to support the economic argument: The more who study the subject the greater the pool from which industry may expect to draw young people into technical or design based careers. Hence it is important that those in industry who are advocates for the subject are aware of arguments other than the economic and use these arguments in their support of the subject.

The second danger is that limiting the number of academically successful young people who study design & technology means that many who go on to professional careers (lawyers, journalists, accountants etc.) will have missed out on the benefits of the subject. They may well be less sympathetic to the design and manufacturing industries.

There is a clear role for the Design & Technology Association here in the way it marshals support for the subject from the commercial world. It has the very important role of ensuring that the messages coming from influential and well known figures in business and industry are not limited to economic arguments but include the other rationales, integrated into powerful and irresistible justifications for all young people to be educated in design & technology. This should not be thought of as the Association adopting a 1984 ‘thought police’ approach in censoring the views of business and industry but rather as an important opportunity to show the intellectual leadership the subject needs.

Recommendation

That the Design & Technology Association, along with key stakeholders in the d&t community, including those from the design and engineering industries, work together, including identifying the necessary funding, to marshal support for a broad view of the purposes of school design & technology to include personal, social and cultural as well as economic aims.
7 Achieving good practice

Teachers are introduced to the features of good practice in design & technology during their initial training but inevitably there is only a limited appreciation of what this entails. Once a teacher is in post, he or she develops further good practice through their day-to-day teaching and learning from colleagues. This is further enhanced through appropriate CPD. It is essential to realise, however, that good practice cannot be achieved in isolation from sound epistemology and clarity of purpose. Any department wishing to develop good practice must first establish agreed statements on (a) what it will be teaching in the subject and (b) why it is teaching the subject. Only once these are established can a department develop an appropriate pedagogy.

Hence any CPD that is provided by the Design & Technology Association or others whose aim is to achieve good practice will need to take all three features (how, what, and why) into account. Visually this can be represented as three vectors of ‘what’ ‘why’ and ‘how’ (Figure 4).

If we imagine a school department’s journey towards better and better practice, these three vectors of activity need to be considered together in the planning and provision of appropriate CPD. Movement along any one vector will be dependent on movement along the other two vectors.

Given the confusion surrounding the epistemology of the subject and the purposes for which it is taught, it is essential that as much as possible of the CPD provision available in the immediate future should consider each of these three features.
As an orthodoxy about subject knowledge is reached and the variety of reasons for teaching the subject become more widely understood, this constraint on CPD may be relaxed. This would allow more concentration on how we teach and a focus on those aspects of what we teach that are seen as necessary or relevant at the time. *Developing Great Teaching* (Teacher Development Trust, 2015) provides a useful summary of research into what constitutes effective professional development for teachers and the DfE has published *Standard for teachers’ professional development* (Department for Education, 2016) which reflects the research findings. Recent summaries of research into effective teaching practices include those from the Sutton Trust (Coe, Aloisi, Higgins and Major, 2014) and Hattie and Yates (2013); effective CPD will need to take these lessons into account. Two key points are that professional development programmes should be sustained over time and must be prioritised by school leadership.

The sort of professional development supported by research and envisaged by the Department for Education goes much further than providing a single day of advice about enhancing students’ public examination performance (important though this is). Hence it is vital that design & technology departments are supported in creating a sustained and substantial professional development programme. Such a programme should (a) support the individual needs of teachers within the department, (b) simultaneously develop good practice across the department and (c) contribute to the modernization of the design & technology curriculum.

It is here that we become torn between the ideal situation – regular, related CPD sessions over time with the opportunity to explore and evaluate the impact of changes in practice – and the pragmatic reality of what most schools can afford, both in terms of the time available for teacher release and the finances available for CPD. One strategy to overcome these difficulties is for schools to collaborate through common CPD days, as is done by some teaching school alliances and Multi Academy Trusts.

The Design & Technology Association has some key roles to play in promoting good CPD to SLTs and in providing CPD that meets the research and DfE criteria for effectiveness.
Much is made of the need for so-called “soft” skills (perhaps better called generic skills): problem solving, communication, team working. In our view, there is nothing ‘soft’ about these in the sense that they are difficult to learn and can only be taught through direct experience carefully orchestrated by the teacher. As they are rarely assessed through formal examinations leading to qualifications they are often neglected. It is worth asking to what extent these skills might be developed through the teaching methods described in this paper. The successful completion of a designing and making task will almost certainly require problem solving and if a young person tackles several such tasks in different contexts over a period of time then it is reasonable to assume that they will become better at problem solving – at least in the general domain of design & technology. Collaborative designing-without-making tasks will require young people to work in teams and communicate. Given repeated exposure to this approach it seems reasonable to assume that these skills will improve. But we must question the validity of these assumptions. Just because it seems reasonable or plausible that these soft skills will be developed does not necessarily mean it is so. Research aimed at probing whether these spin-offs do actually take place in the teaching of design & technology is required. If such spin-offs do occur, how can they be maximised without compromising the integrity of the subject?

**Recommendation**

That key stakeholders from the design and engineering industries and professions support the Design & Technology Association in promoting and providing CPD that meets the research criteria for effectiveness.

**Recommendation**

That key stakeholders from the design and engineering industries and professions work with the Design & Technology Association to establish financial support for effective CPD.

**Recommendation**

That key stakeholders in the d&t community, including those from the design and engineering industries and academia, work with the Design & Technology Association to establish funding for research in response to key questions concerning the effective teaching of design & technology and the benefits of such teaching.
8 Achieving informed stakeholders

SLT and governors, teachers, parents and pupils
Influencing these stakeholders will largely need to be undertaken by the subject leaders in individual schools. The Design & Technology Association has a leadership role here through the provision of advice and guidance on how this might be achieved. This is to some extent dealt within File 2 of the Design & Technology Association’s Subject Leaders File, but more detailed advice would be helpful. This might include some information written specifically for the stakeholder groups which could then be adapted to local circumstances.

It would also be useful if there were an easy-to-use feedback mechanism by which schools could inform the D&T Association of stakeholder response.

Recommendation
That the Design & Technology Association provide information materials, aimed at SLT, governors, teachers, parents and pupils that subject leaders can adapt and use.

Recommendation
That the Design & Technology Association provide a mechanism by which subject leaders can feed the responses of these stakeholders back to the Association.

Teacher trainers and CPD providers
The ITE landscape has changed dramatically in recent years. It is important, therefore, that the Design & Technology Association finds ways to understand that landscape in all its variety – SCITTs, School Direct, Teach First, Teaching School Alliances, Academy Chains and HEIs – and identifies points of contact that enable influence. It is particularly important that all ITE providers deliver a consistent message concerning epistemology and purpose.

We believe that the wide variety of ITE provision builds into a case for the Design & Technology Association to develop training materials that cover the key messages in this paper and that ITE and CPD providers of all stripes can be encouraged to use to inform their work in design & technology.
Noting that the funding implications of the recommendations that follow are considerable, we think that an invitation conference, bringing together as many design & technology ITE and CPD providers as possible, would provide an excellent opportunity to share and discuss the messages in this paper and explore ways of building them into professional development programmes at all levels. Awarding organisations (see below), as significant providers of CPD, should also be included.

**Recommendation**
That the Design & Technology Association work with key stakeholders in the d&t community to establish funding for the development of training materials for design & technology ITE and CPD providers covering the key messages in this paper.

**Government departments and the awarding and assessment organisations**
The Design & Technology Association has, we believe, established good contacts within the Government departments and the awarding organisations. However, we feel that the case for design & technology as part of general education for all is not as strongly acknowledged as we would wish. Also we think it is important that all the awarding organisations honour the spirit as well as the letter of the DfE subject content document. Without this there can be a lack of synergy between the efforts of these stakeholders and the work of the Design & Technology Association.

The challenge appears to be to develop the capacity to achieve a much more proactive stance that enables the Design & Technology Association to inform and contribute to policy at the earliest stages. The recent revision of the KS3 National Curriculum and the development of a new GCSE provide a model for how the D&T Association can wield its influence to great effect. To build on this it would be useful for the design & technology community and its supporters to develop suggestions for action or change that are consistent with the Design & Technology Association’s vision for the subject and which are likely to gain a positive reception from Government by, for example, indicating solutions to issues that the DfE is actively working on.

**Recommendation**
That the Design & Technology Association work with key stakeholders from the design and engineering industries and academia to sponsor and organise an invitation conference for ITE and CPD providers to discuss and disseminate the materials.
Given the significant influence that GCSE content and assessment has on subject practice, it appears critical to ensure that the Chief Examiners for design & technology in the various awarding bodies, along with their colleagues, are to be brought into this conversation about design & technology epistemology and purpose; the suggested invitation conference (see above) should include these people.

**Recommendation**

That key stakeholders from the design and engineering industries and academia work with the Design & Technology Association to encourage the design & technology community and its supporters to develop suggestions for action or change which are likely to gain a positive reception from Government.

**Industry, employers and professional bodies**

These are perhaps the most difficult of the stakeholder groups to influence, given that they inevitably have wide-ranging perspectives but also an instinctive view of the subject of design & technology: their arguments in support of it are almost always entirely economic.

We have made the case above that embracing the wider arguments for including design & technology in the curriculum (including the social, personal and cultural) should lead to more pupils engaging with the subject at GCSE. This will, in turn, provide a larger population of young people with a good understanding of designing, making and technology from which future employees can be drawn. This is a case that needs to be made robustly to industry and employers. (The corollary of this argument is that focussing exclusively on the economic argument is, perversely, leading to a decline in the subject and thus a shrinking of this informed population.)

We suggest that since there is a well identified group of those who have already indicated their positive attitudes towards design & technology in the various campaigns of the Design & Technology Association, it would be reasonably easy to persuade them, or a panel drawn from that group, that this broader vision for design & technology still aligns with their interests while making the subject much more robust for the longer term. A statement of rationale and support for both the epistemological underpinnings and the broad purposes of
design & technology from this core group can be used as a platform to persuade others.

**Recommendation**
That key partners from industry and the professions work with the Design & Technology Association as critical friends to develop a statement of support for design & technology that clearly defines both the epistemological underpinnings and the broad purposes of design & technology education.

**Recommendation**
That these key partners and the Design & Technology Association use this rationale as a platform to persuade others to be active in support of design & technology as a school subject.

**A final thought: Wise men and women**
We suggest that an advisory body composed of influential thinkers, including academics, consultants, industrialists, politicians, civil servants and head teachers be convened. This advisory body would be drawn from both inside and outside of the design & technology education community. Meeting once a year, their remit would be to explore and examine the issues affecting design & technology in schools and to report in the form of strategic advice to the Design & Technology Association and the wider design & technology education community. This advisory body would be focussed on achieving informed stakeholder insight and recommending actions aimed at improving the position of design & technology in schools.

**Recommendation**
That the Design & Technology Association convene an advisory body to explore and examine the issues affecting design & technology in schools from a wide perspective and to report annually in the form of strategic advice.
9 Re-building – necessary but not sufficient

As noted in the introduction, this is the second version of this paper. We published the first version in December 2016 with an invitation to the design & technology community to comment. We hoped this would lead not only to improvements in the document but also provide a better representation of the views of that community. We are very grateful to those who made time to provide critique, in some cases of very generous length.

While all respondents had considerable sympathy with the structure and contents of v1 of the Re-building paper, several pointed to areas they felt had been omitted. Some of these omissions were deliberate on our part, as we wanted to maintain focus on the key features necessary for re-building and at the same time keep the paper as short as was reasonably possible. Some areas hadn’t been considered during the writing but, having had them brought to our attention, we still feel that we can’t give them adequate attention in this paper whilst maintaining focus and reasonable brevity. We do want, however, to both acknowledge the importance of these aspects of design & technology education and at least note their outlines here.

The key suggested additions included the following:
- Assessment of the subject,
- Initial teacher education and recruitment,
- Capacity of the profession to respond,
- Radical re-vision,
- The possibility of political change.

In the sections that follow, each of these is considered briefly to ensure that they do not become forgotten in the wake of reactions to Re-building design & technology v2.

Assessment of design & technology

We deliberately avoided exploring assessment because we wanted to establish what to teach, why to teach and how to teach so that the assessment tail didn’t end up wagging the curriculum dog. It is obvious, however, that assessment is a key issue. We do believe that considerable progress has been made recently in assessment of design & technology without levels in relation to tracking progress and giving feedback to the key stakeholders, pupils and parents/carers. We also know there is considerable variation in the ways that schools approach this. We believe that it is important that methods of assessment are responsive to both what is being
assessed and how this is being taught. It is unlikely that a one-size-fits-all-subjects approach across a school will be of benefit – and that not all school leaders understand this. It is important to note that the assessment for the new single title GCSE appears strong on assessing procedural competence regarding the Non-Examined Assessment. Developing robust assessment of conceptual knowledge in the written paper remains a challenge.

Initial Teacher Education and recruitment
We wanted to concentrate on re-building the subject and felt that dealing with Initial Teacher Education (ITE) and recruitment would distract from the key re-building features. This in no way lessens our view that both the nature of ITE and recruitment to it are serious issues. There is little doubt that ITE has become highly fragmented and the many and varied routes into teaching are confusing for potential applicants. Also, it is clear that a one-year programme provides insufficient time for trainees to acquire the breadth of basic subject knowledge they will need. This is clearly a cause for concern. It is noteworthy that in some other countries (e.g., Malta) the post-graduate qualification required to become a design & technology teacher is a full-time two-year Masters programme.

There is also no doubt that recruitment to ITE has been falling significantly for several consecutive years. But the government report that there is no shortage of D&T teachers. The presumed explanation for this apparent contradiction is that where design & technology teachers can’t easily be replaced, schools are simply contracting D&T departments – being under no pressure by current accountability measures to maintain the subject at full strength. This is clearly a huge worry for the subject. If, however, we can re-build so that there is sound epistemology, clarity of purpose, good practice and informed stakeholders then the status of the subject will increase, more parents will support it, it will gain wider status in industry, and more young people will want to study it. This will impact on both the nature of ITE and recruitment; what you might call a “market pull” argument. So we see re-building as an essential pre-requisite to improving ITE and recruitment.

We have pointed to this in the Recommendations on page 28

Where design & technology teachers can’t easily be replaced, schools are simply contracting D&T departments

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We have confidence that design & technology teachers and subject leaders in schools have the potential to rise to the challenge of re-building the subject.

Capacity of the profession to respond
We noted concerns that design & technology teachers and departments are under so much pressure from curriculum reform, the knock-on effects of national assessment policies such as the EBacc and recruitment problems that they may not have energy to grapple with re-building the subject.

We do have confidence that the majority of design & technology teachers and subject leaders in schools have the potential to rise to the challenge of re-building the subject. But they will not be able to do this alone or unaided. We strongly believe that given support, each design & technology department in every secondary school can contribute to re-establishing the subject as one of significant worth for all young people and reverse the trend in GCSE uptake. This is a task that will require schools to reform their curriculum from the beginning of Year 7, with individual teachers acquiring more extensive subject and pedagogic knowledge and sharing this knowledge by working much more collaboratively in teams. These changes will not be achieved without sustained and substantial CPD.

It is worth noting that there are many able, recently appointed heads of department who will be able to, and will need to, make a significant contribution to this CPD. It is important that these “young Turks” are identified and enabled to play a full part in re-building and taking on leadership of the subject.

We have pointed to this in the Recommendations on page 26

Radical re-vision
We have noted in the Introduction to this paper that we see re-building as a pre-requisite to radical revision. We have deliberately adopted a pragmatic approach which we hope is both inspirational and realistic within the current educational landscape. This does not mean that we are averse to curriculum development that might lead to radical revision. We note that several respondents to v1 are keen to see a sketch of a future for design & technology that is more visionary, attempting to create a picture of a more ideal world of schooling. This is completely laudable and we would want to be involved. It will, however, only take place in the event of a considerable change in the political climate relating to the nature and purpose of schools and schooling. Which brings us to the final area of omission; the possibility of political change.
The possibility of political change

Neil Postman (1996) writes compellingly about the purpose of schooling:

[Some
ting can be done in school that will alter the lenses through which one sees the world; which is to say, that non-trivial schooling can provide a point of view from which what is can be seen clearly, what was as a living present, and what will be as filled with possibility. . . . What this means is that at its best, schooling can be about how to make a life, which is quite different from making a living. Such an enterprise is not easy to pursue, since politicians rarely speak of it, our technology is indifferent to it, and our commerce despises it. Nevertheless, it is the weightiest and most important thing to write about. (p. x)

This view of schools and schooling is, we think, inspirational, but is more than a little removed from the current situation in most secondary schools in England. The importance of qualifications and the performance of schools in enabling their pupils to gain them ride high, almost to the exclusion of all else. And it is this exclusion of all else that has such a debilitating effect on both teachers and pupils. It’s not that qualifications aren’t important. Of course, they are. Yet as far as the overall purpose of schooling is concerned they are necessary but not sufficient.

There should be, as Postman indicates, so much more to schooling. Design & technology has to operate effectively in the current political environment and in response to the prevailing requirements. But it is important that it does this in a way that is true to its intrinsic nature and does not lose sight of the part it could play if political change took place and schools were viewed differently. Keri Facer (2011) has presented an interesting and radical vision of the school and its place in the community. Her vision would place design & technology at the very centre of schools’ relationships with their local communities. Hence it is important that all members of the community of practice are prepared to respond positively to such political change, should it arise. It is for this reason that we made the Recommendation on page 30 concerning the need for regular, well-informed strategic advice.
Recommendations in priority order

In this paper, we have made several recommendations which are gathered together here, ordered in what we consider to be their priority for action. However we do emphasise that we believe all of the recommendations to be of import and do not intend this ordering to suggest that lower priority recommendations are in some way less important.

The emphasis in these recommendations is on the leadership role of the Design and Technology Association; we are not suggesting in any way that the Association can undertake the role of re-building design & technology alone. In particular, we are aware that our recommendations all carry implied costs, in some cases relatively modest and in others significant. These costs are beyond the current budget of the Association. It is important that the whole D&T community works with the Association to help the realisation of these recommendations with both practical and financial support.

All members of the community of practice along with those who support the subject of design & technology and those in positions of influence over the subject need to understand the key roles of Epistemology, Clarity of purpose, Good practice and Informed stakeholders in rebuilding design & technology as a key part of the school curriculum. All need to work with and in support of the Association in this endeavour.

Recommendations

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| 1        | Recommendation concerning achieving good practice (p26)  
That key stakeholders in the d&t community, including those from the design and engineering industries and academia, work with the Design & Technology Association to establish funding for research in response to key questions concerning the effective teaching of design & technology and the benefits of such teaching.  
**Commentary**  
It is essential that the work of the Association and others attempting to re-build the subject is informed by robust, up-to-date data so that the subject and its ambition can be seen to be research-informed. |
| 2        | Recommendation concerning achieving sound epistemology (p22)  
That the Design & Technology Association, along with key stakeholders in the d&t community, including those from the design and engineering industries, work together, including identifying the necessary funding, to establish and promote an agreed orthodoxy regarding the core of knowledge, understanding, skills and values that underpin school design & technology.  
**Commentary**  
It is important that there is support for the development of a wide agreement on subject knowledge to underpin other recommendations |
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| 3 | Recommendation concerning *achieving clarity of purpose* (p23)  
That the Design & Technology Association, along with key stakeholders in the d&t community, including those from the design and engineering industries, work together, including identifying the necessary funding, to marshal support for a broad view of the purposes of school design & technology to include personal, social and cultural as well as economic aims.  
**Commentary**  
It is important that there is support for the development of a wide agreement on the purpose of d&t to underpin other recommendations |
| 4 | Recommendation concerning *achieving informed stakeholder perception with particular regard to SLT, governors, teachers, parents and pupils* (p27)  
That the Design & Technology Association provide information materials, aimed at SLT, governors, teachers, parents and pupils that subject leaders can adapt and use.  
**Commentary**  
It is important to enable d&t departments to influence the views of local stakeholders |
| 5 | Recommendation concerning *achieving informed stakeholder perception with particular regard to SLT, governors, teachers, parents and pupils* (p27)  
That the Design & Technology Association provide a mechanism by which subject leaders can feed the responses of these stakeholders back to the Association.  
**Commentary**  
It is important that the D&T Association is informed about the views of local stakeholders and their responses to the information materials supplied. |
| 6 | Recommendation concerning *achieving informed stakeholder perception with particular regard to Teacher trainers and CPD providers* (p28)  
That the Design & Technology Association work with key stakeholders in the d&t community to establish funding for the development of training materials for design & technology ITE and CPD providers covering the key messages in this paper.  
**Commentary**  
It is important to provide well-funded CPD that supports the development of an agreed orthodoxy amongst those who provide ITE and CPD |
| 7 | Recommendation concerning *achieving Informed stakeholder perception with particular regard to Teacher trainers and CPD providers* (p28)  
That the Design & Technology Association work with key stakeholders from the design and engineering industries and academia to sponsor and organise an invitation conference for ITE and CPD providers to discuss and disseminate the materials.  
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</table>
| 8        | **Recommendation concerning achieving good practice** *(p26)*  
That key stakeholders from the design and engineering industries and professions support the Design & Technology Association in promoting and providing CPD that meets the research criteria for effectiveness.  
**Commentary**  
It is important that CPD for D&T is seen to have support from a wide range of stakeholders |
| 9        | **Recommendation concerning achieving good practice** *(p26)*  
That key stakeholders from the design and engineering industries and professions work with the Design & Technology Association to establish financial support for effective CPD.  
**Commentary**  
It is important that there is funding to support high-quality CPD |
| 10       | **Recommendation concerning achieving informed stakeholder perception with particular regard to Industry, employers and professional bodies** *(p30)*  
That key partners from industry and the professions work with the Design & Technology Association as critical friends to develop a statement of support for design & technology that clearly defines both the epistemological underpinnings and the broad purposes of design & technology education.  
**Commentary**  
It is important that key stakeholders are enabled to promote the subject with a unified voice |
| 11       | **Recommendation concerning achieving informed stakeholder perception with particular regard to Industry, employers and professional bodies** *(p30)*  
That these key partners and the Design & Technology Association use this rationale as a platform to persuade others to be active in support of design & technology as a school subject.  
**Commentary**  
It is important that key stakeholders are enabled to promote the subject with a clear view of its content and its purposes |
| 12       | **Recommendation concerning achieving informed stakeholder perception with particular regard to Government departments and the awarding and assessment organisations** *(p29)*  
That key stakeholders from the design and engineering industries and academia work with the Design & Technology Association to encourage the design & technology community and its supporters to develop suggestions for action or change which are likely to gain a positive reception from Government.  
**Commentary**  
It is important that Government has a clear understanding of the subject’s content and purposes and recognises that these have a wide base of support. |
| 13       | **Recommendation concerning harnessing the insights of influential thinkers both inside and outside the design & technology education community** *(p30)*  
That the Design & Technology Association convene an advisory body to explore and examine the issues affecting design & technology in schools from a wide perspective and to report annually in the form of strategic advice.  
**Commentary**  
It is essential that the Association has high quality advice and guidance on how to proceed in its use of the research at its disposal |
Appendix 1: Big Ideas for Design & Technology

Introduction
In deciding what to teach in design & technology it is important to consider both the nature of design and the nature of technology. These have quite separate intellectual traditions and one of the tasks of design & technology as a school subject is to bring these two traditions together in a way that is both workable and rigorous.

Design
Designing is a complex activity. Lawson (2004) makes an intriguing analogy with playing chess:

*Designing then, in terms of chess, is rather like playing with a board that has no divisions into cells, has pieces that can be invented and redefined as the game proceeds and rules that change their effects as moves are made. Even the object of the game is not defined at the outset and may change as the game wears on. Put like this it seems a ridiculous enterprise to contemplate the design process at all!* (p. 20)

Interestingly, this mirrors to quite a large extent the requirements of the conceptual challenge that young people will tackle in the new single title GCSE.

Ropohl (1997) has further described this activity as requiring:

*The development and design of a novel technical system, anticipat[ing] the object to be realised through mental imagination. [The designer] has to conceive of a concrete object which does not yet exist, and he [sic] has to determine spatial and temporal details which cannot yet be observed, but will have to be created by the designing and manufacturing process.* (p. 69)

“Conceiving . . . what does not exist” (Buchanan, 1996) and “developing and designing a novel . . . system” (Ropohl, 1997) indicate that pupils will, on occasion, be required to make conceptual design decisions. “Developing and designing a . . . technical system” (Ropohl) indicates that pupils will need to make decisions about the way their design will work, that is, make technical design decisions. “Spatial
and temporal details which cannot yet be observed” (Ropohl) indicates that pupils will need to make decisions about the appearance of their designs, that is, aesthetic decisions. Finally, “created by the . . . manufacturing process” (Ropohl) indicates that students will need to consider how they will make their design, that is, constructional decisions.

Ropohl (1997) does not explicitly consider the user, yet product designers have commented on how important it is to consider the user when developing design proposals and this is now explicit in the design & technology National Curriculum and the new GCSE specifications. For example, Jonathan Ive, Apple’s Chief Design Officer, states, “the design of an object defines its meaning and ultimate utility. The nature of the connection between technology and people is determined by the designer” (Department for Education and Employment, 1999, p. 14). This indicates that some of the decisions made by pupils should be informed by a consideration of the user. As these considerations will be broader than any one group of users, such considerations are perhaps better described as market considerations. This indicates that pupils will need to make decisions related to the market for their product.

Decisions in these five domains (conceptual, technical, aesthetic, constructional and marketing) are not made independently of one another, for as Buchanan (1996) states, “a designer must attend simultaneously to many levels of detail and make numerous decisions as he or she designs.” (p. 7).

Hence, we have adopted a design decision making model as a useful way of describing pupils’ design activity in designing and making activities and used this in the “Good Practice” section of v2 of the rebuilding paper (See Figure 3, p15).

**Technology**

Technology is not easy to define, as different philosophical positions lead to different definitions. Kelly (2010) in his provocative book *What technology wants* discusses the idea of autonomous technology in terms of three interacting influences:

> The primary driver is pre-ordained development – what technology wants. The second driver is the influence of technological history, the gravity of the past,

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5 *What Technology Wants* focuses on human-technology relations and argues for technology as the emerging seventh kingdom of life on earth. The book invokes a giant force – the *technium* – which is "the greater, global, massively interconnected system of technology vibrating around us"
as in the way the size of a horse’s yoke determines the size of a space rocket. The third force is society’s collective free will in shaping the technium, or our choices. (p. 181)

From Kelley’s perspective, it appears that the influence that mitigates against technological inevitability (society’s free will) is the smallest of these influences. He entrenches this position by describing technological development in terms of a set of trends that contribute to the expression of specific technologies and how they might progress. For example, in this set he includes increasing sentience. This may give cause for concern given that deeply embedded in popular culture is the idea of machines becoming self-aware and either dominating human life, as in the film Metropolis (made in 1927), or deciding that humanity is antithetical to its own existence and actively waging war on humanity, as in the Terminator films (made in 1984, 1991, 2003 and 2009).

Nye (2006) rejects this idea of technological autonomy:

> From the vantage point of the present, it may seem that technologies are deterministic. But this view is incorrect no matter how plausible it may seem. Cultures select and shape technologies, not the other way around. . . . A more useful concept than determinism is technological momentum, which acknowledges that once a system such as a railroad or an electrical grid has been designed to certain specifications and put in place it has a rigidity and direction that can seem deterministic to those who use them. (p. 212)

Arthur (2009) takes a different starting point in considering the nature of technology and the way it evolves. He argues that technology can be viewed as the exploitation of phenomena revealed by science. He rejects a simplistic “technology is applied science” view but is adamant that it is from the discovery and understanding of phenomena that technologies spring. He notes that:

> It should be clear that technologies cannot exist without phenomena. But the reverse is not true. Phenomena purely in themselves have nothing to do with technology. They simply exist in our world (the physical ones at least) and we have no control over their form and existence. All we can do is use
them where usable. Had our species been born into a universe with different phenomena we would have developed different technologies. And had we uncovered phenomena over historical times in a different sequence, we would have developed different technologies. (p. 66)

Naughton (in Banks, 1994) adds further weight to the rejection of a simplistic applied science view of technology when he writes that technology always involves “ways of doing things . . . a complex interaction between people and social structures on the one hand and machines on the other” (p. 12). Naughton’s description immediately complicates the design & technology curriculum in that a consideration of machines, which many would see as a basis for a technology curriculum, becomes insufficient.

Our view, informed by the preceding discussion, is that design & technology as a school subject should take seriously the following aspects of technology:

- That technology is built on phenomena in the real world and pupils should develop understanding of the range of key phenomena that technology uses.
- That technology is a human activity and pupils should both experience a wide variety of technological activities and learn to consider the human and social implications of such activity.
- That our current technologies are built on previous technologies and that, in turn, the technologies being developed today will have implications for future technologies. Pupils should, therefore, develop understanding of these relationships and develop a critical mind-set about the use of technologies.

**Concerning Big Ideas**

The work of Harlen and colleagues (e.g., Harlen, 2010) in developing statements of content for science education that were true to the nature of the subject may provide us with a useful model. They divided the content into ideas about science (that is, the way that science as a discipline works), and ideas of science (the key intellectual building blocks of science). What might be developed if the design & technology community adopted such an approach? What would we list as ideas “of” and “about” design & technology?
Ideas about design & technology might include:

- Through design & technology people develop technologies and products to intervene in the natural and made worlds;
- Design & technology uses knowledge, skill and understanding from a wide range of sources, especially but not exclusively science and mathematics;
- There are always many possible and valid solutions to technological and product development challenges, some of which will meet these challenges better than others;
- The worth of technologies and products developed by people is a matter of judgement;
- Technologies and products always have unintended consequences beyond intended benefit which cannot be fully predicted by those who develop them.

Ideas of design & technology might include:

**Knowledge of materials**
Design & technological activity requires the use of materials. And if someone is going to use materials he or she will need to know something about them. So, what would need to be known? Clearly the idea of different materials having different properties is essential. Given the importance of eco-footprint then it will be useful to know something about sources of materials and how they are refined to the state where they are useful. And given the finite nature of the material world it would be useful to know something about the estimated reserves of materials, especially those that are particularly useful and in short supply. This can be listed as:

- Sources
- Properties
- Footprint
- Longevity

Making decisions about which materials to use are therefore complex and requires much more than a “science” understanding of materials. Marc de Vries (2007) commented on this amusingly and with insight when he wrote, “there’s no such thing as a good electron.” Materials have the properties they do, intrinsically neither good nor bad, but in choosing which material to use we have to make a judgment which requires a range of knowledge and understanding. And, of course, in design & technology education we want young people not only to learn how to make such complex judgments for themselves, but also to critique the judgments made by others. Hence, we believe that deliberately teaching something about materials in general is essential.
Knowledge of manufacturing

The next step, of course, is to be able to do something with these materials, and so manufacturing is an important idea of design & technology. In broad sweep terms, manufacturing can be divided into four main methods: subtraction, addition, forming and assembly and overlaid on each of these are methods of finishing. At the moment, addition is receiving considerable attention as additive manufacture is being used to produce items of both simplicity and complexity at very different scales to the point where it will almost certainly be possible to “print” organs for transplant. So, this important area of design & technology can be subdivided as:

- By subtraction
- By addition
- By forming
- By assembly
- With finishing

Deciding how a product will be made is also complex, as there will be many ways to achieve a particular “making” outcome. This is further complicated in school in that it takes time to develop the knowledge of making processes into skilful use of those processes. So, we believe that deliberately teaching about manufacturing in general and particular making skills is essential.

Knowledge of functionality

Most of the made world has to “work” so some knowledge of achieving functionality is required. Three categories seem useful: powering, controlling and structuring. Controlling is moving on in leaps-and-bounds with the embedding of electronic intelligence into everyday products becoming commonplace. The technology to achieve this is within the reach of schools through microcontrollers such as PICAXE and Arduino. Equally, providing power is developing in interesting ways in response to concerns about climate change, with a growing emphasis on the use of renewable power sources. So, this important aspect of design & technology can be subdivided as:

- Powering
- Controlling
- Structuring

Deciding how something is going to work involves complex decision making. This is well exemplified by the Bayliss Wind Up radio – a radio powered by a battery isn’t useful when batteries are in short supply or too expensive to buy. Powering by means of human energy stored in a wound-up spring that was structured so it could control the release of
this energy slowly over time that could be used to operate a
dynamo that powered the radio is an elegant application of
the three Big ideas concerned with function. Hence, we
believe that deliberately teaching something about achieving
function in general is essential.

Knowledge of design
Very little of the made world comes into existence except
through purposeful design. Knowledge of design is crucial
and recent HMI reports have indicated that teaching
designing has long been the Achilles heel of the subject. Four
broad methods will be needed: (a) identifying peoples’ needs
and wants, (b) identifying market opportunities, (c)
generating, developing and communicating design ideas, and
(d) evaluating design ideas. This set of methods taken
together and used sensibly enables young people to develop
the abilities to envisage outcomes that do not yet exist and
create them through choosing and using materials and
embedding function. Hence this important idea of design &
technology can be subdivided as:
• Identifying peoples’ needs and wants
• Identifying market opportunities
• Generating, developing and communicating design ideas
• Evaluating design ideas

It is well known that designing is difficult and can only be
learned by tackling the activity itself (Choulerton, 2015). We
are convinced that identification of a variety of design
strategies and explicitly teaching pupils how to use these is
important in design & technology.

Knowledge of critique regarding impact
The question that immediately follows is to what extent are
designed outcomes of worth?

How do they affect the lives of those who use them and those
that make them? How do they affect the planet? Here we
immediately see the need for critique. This is different from
evaluation as defined in “evaluating design ideas”, in which
the evaluator asks of a design idea/outcome: “Did it do what
it was supposed to?” In critique the question becomes: “Is
what it is supposed to do worth doing and what are its
unintended consequences?” Two broad areas of critique are
stewardship and justice. Critiquing for stewardship involves
considering life cycle analysis and speculating about different
economic models – the currently predominant linear
economy and the circular economy as espoused by, for
example, the Ellen MacArthur Foundation (2012, 2013). In a
just world, all people should be able to live in freedom from
hunger and fear and have shelter from harm. They should
have opportunities to pursue happiness and make the best
of their lives. The made world, full of deliberately designed products, environments and systems, must be held to account by critique. So, critiquing the outcomes of others as well as their own is an important pupil activity. This important idea of technology can be sub-divided as:

- For justice
- For stewardship

This critique should take place in a broad sweep way at the level of an environment, a system or product, as well as at a more detailed level in which the decisions concerning the nature of small features within any of these can be subject to critical scrutiny.

Figure 1, p7, summarises the Big Ideas.

Note also that to gain a holistic picture of the subject, all the ideas “of” and “about” design & technology will need to be considered together as they interact with one another when design & technological activity plays out in the hands of industrialists, politicians, the general public, designers, engineers and technologists.

**In conclusion**

The above consideration of the ideas “of” and “about” design & technology is at a high level of summary and considerable detail will need to be added as teachers devise a curriculum that incorporates these ideas. And it is important that such detail is added in a way that embraces a wide range of approaches to design incorporating, for example, the practices of different cultures in different places and at different times. In this way, an over-emphasis on modern Eurocentric approaches can be avoided and the insights of indigenous peoples can be taken into account.
References


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David and Torben have been working together in design & technology education, on and off, for around 20 years. D&TforD&T is a means to enable us to disseminate our work and communicate with the design & technology community and its main vehicle is the D&TforD&T website. This allows us to bring together in a single place the things we are working on and thinking about, both together and individually.

The website also profiles associates with whom we frequently work – Nick is a key member of this group.

In particular, by doing some of our work and thinking more publicly we hope to draw in other colleagues from the D&T education community.

The core things we use the website for include:

- **Blogging:** to share our thoughts on various things in the broad areas of D&T and education as well as drawing attention to interesting things we find elsewhere on the web.
- **Noting courses and other CPD activities such as network meetings that we are involved in running.** We also mention other events, such as conferences, that we might be either speaking at or planning to attend.
- **Making available resources we have developed for teachers and pupils.** We also use this part of the website to share our plans for resource development and seek both commentary on these plans and support for the development work – such as help with trialling.
- **Discussion around and publicity for other projects we are involved in.**
- **Sharing the reading we are doing.** We have found, over the years, that discussing and sharing our reading has been an important route to developing and keeping fresh our thinking about D&T and education as well as helping us keep (each other) current with new developments. We want to share this reading and thinking more widely by noting the books, papers, reports and articles that are stimulating us.

https://dandtfordandt.wordpress.com