Big Ideas for Design & Technology
A Working Paper

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D&TforD&T Working Papers

David, Torben, often with colleagues, write ‘Working Papers’ to explore issues of relevance to design & technology education.
We welcome comments on these papers which can be made via our website at
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Contributors

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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.

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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

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:

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

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:

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

“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 (Figure 1).

![Figure 1: Pupil design decisions](image-url)
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, 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)

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1 *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.”
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.

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.

Figure. 2, on the next page, summarises the Big Ideas.
Figure 2
Big Ideas for design & technology

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

- Properties
  - Sources
  - Footprint
  - Longevity

- Addition
  - Subtraction
  - Forming
  - Assembly
  - Finishing

- Needs and wants
  - Market opportunities
  - Generating developing and communicating ideas
  - Evaluating

- For justice
  - For stewardship

- Design

- Critique

- Manufacture

- Functionality

- Materials

- Fundamental nature

- D&T
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


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/or 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.

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