Developing a Strong Research-Base

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Abstract
This keynote address gives an overview of some of the key factors in developing a strong research base for design and technology education. In particular, the deconstruction and reconstruction of the conceptual basis of design and technology as a subject, securing and making accessible the records of the work of past researchers, establishing a strong framework for the on-going international conversations that will generate progress, and ensuring that new researchers are supported in establishing their place within this framework. These are illustrated through a discussion of the ideas culture that has shaped design and technology as a school subject in the UK, and the weaknesses of current models of designing and representations of technological knowledge. Recent contributions are noted, such as Doyle's concept of 'technicity', which might provide a stronger basis for future developments. Recent research agendas are restated and the key refereed research publications are noted. Arguments are put forward for the merits of looking back to the 1970s, when design and technology was emerging, in order to cast new light on current positions. Reference is made to three new publications targeted at supporting this agenda and, in particular, *Designerly Activity and Higher Degrees*, which was based on a seminar series given by Professor L Bruce Archer.

Key words
design and technology education, research, ideas culture, designerly activity

Introduction
Research activity has purposes to serve at three distinct levels:
- in supporting the emergence of a subject (or discipline);
- as an aspect of the work of an academic department;
- as a response to personal goals.

This keynote address seeks to give an overview of some of these purposes and to indicate how new researchers can become engaged in research concerning design and technology education.

In higher education design and technology is often represented by individuals or small groups of staff. As such, the subject's position is potentially weak, and it is only through combining efforts that a strong subject discipline has emerged and can be sustained. Individual researchers and small research groups can make their contributions, but the field is too wide not to found these contributions on the work of others and to seek to share the outcomes. Those engaged in design and technology education are used to taking holistic viewpoints, where the value of the whole can be seen to be greater than the sum of the individual parts, and such a holistic perspective needs to be taken concerning research and curriculum development in design and technology education. The potential risk is not only that isolated, small-scale research programmes might continually be expending effort in reinventing the wheel, but also that the enormity of the research agenda can de-motivate would-be researchers. Knowledge of how to access prior art and current research agendas should enable new researchers to position their activities with confidence and as part of the continuing research effort.

Conferences and research publications are important opportunities to take part in the on-going conversation which lies at the heart of research. They are key events for the researcher in design and technology education as they are for those in any other discipline. The illustrations included of on-going discussions and conceptual debates have their origins in the 1970s. This is the decade that preceded the emergence of 'design and technology' and concepts from the period have both shaped, and plagued, its evolution. Understanding their origins is part of exploring how some of the current shackles that seem to be hampering progress can be loosened.

On-going conversations: the high ground
It is the ideas culture which shapes the development of a subject area like design and technology. This initial discussion concerns some key aspects of the ideas culture that have driven the subject's development over the last few decades.

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In the 1970s, three major research and curriculum development projects were completed in the UK:
- **The Keele Project** (Keele University, 1971), which was a re-examination of craft-based teaching and learning in schools.
- **Project Technology** (Loughborough University, 1971), which was exploring the nature and role of technologies (engineering) in relation to school project work.
- **Design in General Education** (Royal College of Art, 1979) which set out to identify the nature of designing in schools and the contributions of different areas of the curriculum.

These were important contributions to the on-going debate about 'design', 'craft' and 'technology'. How are these areas to be defined and understood? How are their inter-relationships to be explored? Craft, design and technology (CDT) syllabuses of the 1980s were perhaps some of the early manifestations of these discussions and one of the more important documents of the period was the Assessment of Performance Unit (APU) publication *Understanding Design and Technology.* This report introduced the concept of design and technology as follows:

The dominant feature of activity in the area of design and technology is the bringing together of skills, experience, knowledge, understanding, imagination and judgement, whatever their limitations, in the execution of a specific task. In practice, it involves the integration of a complex of activities which are specific- because they relate to a particular need; inventive - because they call for a creative response; effective - because the end result should reflect a better fit or match between need and provision than existed formerly; and evaluative because the designer is called upon, throughout the process, to exercise value judgements of many kinds when arriving at the proposed solution... This complex of activities can be broken down for assessment purposes, if it is considered as a summation of skills, knowledge and values.
(Hicks, 1982:2)

So, in 1982 it was well understood that design and technology was 'task-based' and that it required creativity and sound judgements. These matters have never really been contentious, except perhaps in the manner and effectiveness of their delivery. The implicit, and rather more contentious, debate that was very active at the time, which continued through the evolution of the UK National Curriculum in the 1990s and which continues still, concerns the relationship of designing and knowledge. The position in 1982 was stated as follows:

In one sense, every sort of design activity is built upon a related form of knowledge, specific to the type of problem involved - in other words, upon its relevant technology. Most people, however, would recognise that some design activities are more technological than others, in the sense that they rely more upon information about the nature and behaviour of materials and processes, particularly of the more resistant materials and the more power-using processes. Whilst much of this report is applicable to other areas of design-related activity in schools, the emphasis is on this more explicitly technological activity, as can be seen from the detailed analysis of the knowledge component of the framework proposed here.
(Hicks, 1982:5)

This position was never satisfactory, and is essentially arguing that some technologies are 'more technological' than other technologies. It is a weak position, but surprisingly persisted throughout much of the debate concerning the emergence of the National Curriculum in the late 1980s and 1990s. (A more extended debate concerning this issue can be found in Norman, 1998). The conception of technology as related essentially to particular information types is plainly flawed. Consider the following passage recently written by Dasgupta.

… technology is commonly viewed as the "mere" application of scientific principles to the solution of practical problems. History gives lie to this perception. To begin with, if science is concerned with the understanding

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of nature, technology endeavours to master or harness it for practical ends. This distinction in aims has profound implications for how nature or natural phenomenon is perceived by science and by technology. In essence, the two approaches encapsulate what might be called complementary views. Furthermore, the practical necessity for mastery or control has far exceeded in urgency the purely intellectual and emotive desire to understand. Man had been making, treating and casting metals and alloys; constructing roads, bridges, dwellings, and public buildings; crafting boats and ships; and shaping the instruments and engines of war many thousands of years before the rational comprehension of their respective underlying principles could even be contemplated.

Historically, technology is older than Homo sapiens. It reaches back to the hominids and the stone tools of the Lower Paleolithic Age about two and a half million years ago. Science, even in its earliest, most speculative form, is only a few thousand years old, and science as we know it began in about the fourteenth century. The mental processes of inventing artifacts, thus, can scarcely be held to be an ancillary of the mental process of scientific discovery. Indeed, it is fair to claim that the earliest manifestation of creativity in humans and their immediate ancestors was in the realm of technology – much earlier, even, than the cave art we so admire, which is known to have been practiced twenty or twenty-five thousand years ago. Clearly, technology as a creative process deserves to be pondered in its own right, quite independent of science, although we might expect to see some points of contact, especially in the past three centuries. (1996, vii-viii)

There is something fundamental to human evolution about technology, and this was further explored by Doyle (2004) in a fascinating account of the concept of technicity:

Technicity is the capacity of behaviourally modern humans:
- *to deconstruct and reorder objects; and*
- *deploy an external memory system. (ibid:69)*

(Or, at the risk of over-simplifying, make things and draw!) Doyle argues that technicity played a key role in the speciation event that led to our species radiating from Africa; that it is the basis of writing (which was first used for accountancy not to record speech); and that it is the basis of the formation of shapes, which are the basis of language. And so:

If further studies support the technicity hypothesis then reappraisal of the conceptual framework underpinning the educational curriculum might be of benefit: a technology of language rather than the language of technology. (ibid:67)

One of the reasons that perhaps there have been so many difficulties in getting to grips with this area was expressed by Daley in 1984:

To talk of propositional knowledge in this area, or to make knowledge claims about the thinking processes of designers, may be fundamentally wrong-headed. The way designers work, may be inexplicable, not for some romantic or mystical reason, but simply because these processes lie outside the bounds of verbal discourse: they are literally indescribable in linguistic terms. (299)

And there have been difficulties in dealing with the knowledge component of technology. McCormick concluded his Maurice Brown Memorial Lecture in 1999 as follows:

The way those involved in design and technology have refined their views on processes, albeit slowly, now needs to be developed to incorporate those of knowledge. My exploration of this kind of knowledge has sought to suggest that we should not look in the first instance to the abstraction of science and mathematics, but to the practical knowledge used by

technologists. This search does not imply a swing from 'process' to 'knowledge', but the search for the relationship between the two. Nor does this imply that science and mathematics are to be ignored, but that their role in the design and technology lesson may be more complex than assumed. (13)

Williams (2004) recently reported an on-going QCA/NESTA[1] Project *RECORDAT (RECOgnising Real Design And Technology)* which is seeking to 'provide (pupils), their teachers and other interested parties with examples of projects, supporting illustrations and text, which outlines a knowledge discipline that underpins the subject' (1999). So, it is clear that the search to understand the knowledge component of design and technology continues.

During the 1990s it had almost become accepted that design and technology would come to be regarded a composite noun. This has its origins in the *National Curriculum Design and Technology Working Group Report* chaired by Lady Parkes in 1988:

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. (Accordingly we use design and technology as a compound noun taking the singular form of verbs in what follows.) (DES and Welsh Office: 2)

This resolution (of design and technology as a unitary concept) is more satisfactory than the explanation: either 'design' and 'technology' are separate entities or they are not, or, perhaps like electrons, it must be accepted that they have a dual existence. In the early 1980s, it would have been argued that knowledge, skills and values were being taught across the curriculum and that design and technological activity brought them together through designing. By the late 1980s, and through the 1990s, design and technology is being seen as a subject that contains at least some aspects of 'design' and 'technology' in an inseparable way. From this position it is all but inevitable that attempts will be made to define that area of design that lies within design and technology, and similarly the technology it contains, and, it is but a short step to the idea of designing as a 'process' and technology as 'information' or the 'reconstruction of scientific knowledge'. Figures 1 and 2 show typical models of 'technological knowledge' and 'designing' in this tradition.
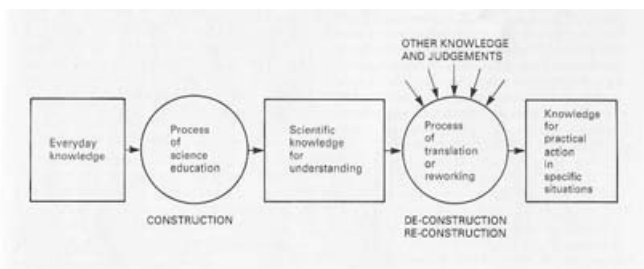
Figure 1. Construction and de-/re-construction of scientific knowledge (Layton, 1993: 59)
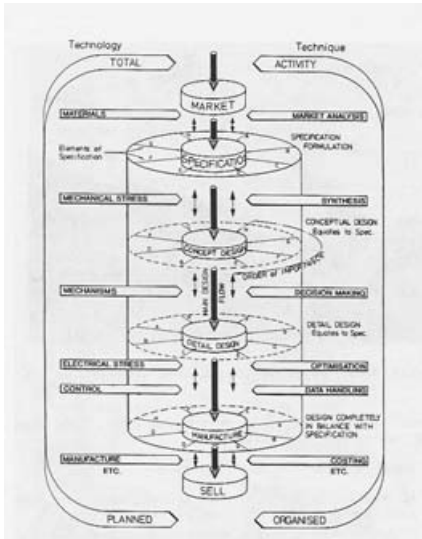
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Figure 2. **Total design activity model (Pugh, 1990:11)**

A more credible position is that the concepts we currently term 'design' and 'technology' are intimately connected and that these models are poor starting points from which to make further progress. The discussion of the need for a new paradigm, which was the focus of DATA's[2] International Research Conference in 2002, and the increasing concern about 'creativity in crisis' (e.g. Barlex, 2003) were essentially a result of leaving this discussion unresolved (see also Kimbell, 2003). The introduction of the UK National Curriculum in 1990 effectively froze the subject's conception within the most influential ideas of the late 1980s, and these were not a secure enough specification to freeze. The parallel dissatisfaction which has emerged with the model of design and technology used in Scotland has led to the re-introduction of a craft-based curriculum (Dakers, 2003). And, more generally, the debate is now returning to the role of values in design decision-making and a number of recent conferences have focused on this issue (e.g. PATT-13 in Glasgow, June 2003). These matters are not resolved. An exploration of the role that the philosophy of design can make to their resolution was the subject of the 2003 John Eggleston Memorial Lecture, which was given by Marc de Vries.

If you begin to accept the concept of technicity as the trigger for human evolution, then it is unsurprising that Governments around the world keep faith, and have faith, that design and technology can play a vital role within their education provision. But equally, it would not be surprising if some decision-makers temporarily lost their convictions as a response to some of the poorly-founded curriculum development that has taken place.

Participation in the on-going conversations
In 2003 an independent review of literature in the last decade concerning design and technology in schools was published by Harris and Wilson. It was funded by the DfES[3] and is available to download from **http://www.dfes.gov.uk/research/data/uploadfiles/RR401.pdf** . It does offer some encouragement for researchers in design and technology education by saying that 'we were impressed, and somewhat overwhelmed, by the number of references to D&T in the literature mainly produced by the community of practice' (Harris and Wilson, 2003a:60). The review provided a refreshing opportunity to view our subject through the eyes of researchers from outside of the design and technology community, as it was conducted by staff from the Scottish Council for Research in Education and should encourage some reflection on what has been achieved. 'Overall the searches reveal a subject that has come a long way in the twelve years since its inception' (Harris and Wilson, 2003b:2), but many of us would disagree with the notion of design and technology beginning with the introduction of the National Curriculum in 1990.

The whole report should be read by all researchers in the design and technology field, but it is interesting to note their general conclusions:

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Our general conclusion is that despite the number of references to D&T in the literature few were research-based in terms of meeting peer-review standards. Many of the papers have been written by advocates of the subject and where research does exist, it tends to be small-scale or action-based. While we recognise the importance of involving users, we recommend that the development of the D&T curriculum and learning and teaching would benefit from more funded and systematic research in D&T generally.

Specific issues which could be explored are as follows.
- *Can a model of research for D&T, which includes 'users' be developed?*
- *Can the claims of supporters that D&T encourages critical thinking, problem solving and creativity be substantiated?*
- *What are the most effective ways of learning within D&T, with particular reference to collaborative learning and the developing (of) higher level skills?*
- *How do good/effective teachers teach D&T, organise their classrooms/workshops, equipment, access resources and keep up-to-date?*
- *What are the most effective ways of encouraging design and creativity in D&T at all stages?*
- *How can ICT be used effectively by pupils and teachers to support D&T at all stages?*
- *What is the impact of gender/ ethnicity/ disability on D&T? How can opportunities for all, both pupils and teachers, be extended in D&T?*
- *What does industry/business want from D&T and how can productive relationships with them be extended?*
- *Do up-to-date resources impact on pupils' achievements?*
- *Can outcomes from schools with different levels of resources be compared?*

Finally, there is now an on-going need to monitor the effects of removing D&T from the core at Key Stage 4.
(Harris and Wilson, 2003:a:62)

After reviewing the design and technology literature, these are the questions to which Harris and Wilson felt answers were outstanding. Research agendas like this emerge as part of this on-going conversation. They appear in formal reviews and as a result of conferences. As the traditional IDATER[4] conferences ended in 2001, the decision was made that IDATER would go on-line. In 2001, a publication was produced concerning the emerging international research agenda (edited by Norman and Roberts). As well as discussing the research agenda, this publication also contains a discussion of action research, which is the basis of a model of research including users that was being sought in the DfES literature review. This publication, over 400 papers from the IDATER conferences and The Orange Series publications can all be downloaded freely from **http://www.lboro.ac.uk/idater/**. One publication in the *Design Curriculum Matters* strand of the Orange Series might be of particular interest, namely *The Nature of Research into Design and Technology Education*. This was published in 1992 and contains three separate articles:

- **The Nature of Research in Design and Design Education** by Bruce Archer, which was based on a keynote address given at IDATER91.
- **Research Into Primary Design and Technology** by Ken Baynes.
- **Design in Education: a select bibliography** by Phil Roberts.

These were all important contributions, described in the introduction as follows:

We have decided to begin with a discussion of the nature of research in this area. There seems to be agreement between practitioners and academics that research is needed. However, it is not always so clear WHAT needs to be investigated, HOW to investigate it and WHO should do the work. Those are the issues we set out to explore in this publication.

We tackle it in three ways. First Bruce Archer addresses the broadest issues of research, making the links between design, design education and the role of teachers in any

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research programme. Next Ken Baynes looks more closely at the Primary field, reviewing existing theory and attempting to identify the right focus for future work. Finally, Phil Roberts presents an annotated Bibliography covering some of the essential reading that gives access to the 'ideas culture' of design and technology as an aspect of education in the widest sense.
(ibid:6)

As a flavour of what can be found in this publication, consider this passage in which Bruce Archer is describing the designerly approach:

A designerly approach to curriculum or course design might be to ask:

'What sort of capability profile would a pupil need to exhibit in order to be seen to have attained the target in question?'

and then:

'What are the categories of knowledge, skills and values that contribute to such a profile?'
'What are the components of each category?'
'What kind of learning experiences are likely to imprint each of these components of knowledge, skill and value?'
'How can such learning experiences be provided?'

and so on, from the general to the particular, down to exercise design, performance assessment design and resource allocation. There is every reason for teachers of design and technology to use the techniques with which they are familiar to attain the objectives to which they are committed.

I opened this address with the question: 'What kind of research is appropriate to the study of education through design and technology?'

My answer has been:
'The designerly mode of enquiry is entirely appropriate to the study of education through design and technology. It is also less prone

than the scholarly or scientific modes of enquiry to distortions arising from conflicts between the mental set of the practitioner and the mental set required of the researcher'.

That is not to say that scholarly and scientific research methods do not have their place in educational research. I do say that scholarly and scientific methods need to be executed by people properly trained in their employment.
(ibid:12-13)

The support for this mode of enquiry grew during the 1990s. The two kinds of knowledge implied here, that generated by professional researchers (e.g. at universities and research institutes) and that generated by teachers researching in a designerly mode (although the concept was expressed differently) were labelled Mode 1 and Mode 2 in 1994 (Gibbons et al). In 1998 Hargreaves (the then recent Chief Executive of the QCA) argued that 'knowledge creation and dissemination in education must now move into Mode 2: teacher centred knowledge creation through partnerships'.

So, all-in-all, there already exists substantial guidance concerning worthy research areas and how to set about tackling them. Of course, researchers have already begun responding to this agenda.

These responses are not necessarily a matter of cause and effect. Expressions of research agendas appear occasionally, but they are essentially summaries of positions which individual researchers might have held for some time concerning current issues and priorities. The focus of DATA's international conference in 2004 was 'Creativity and Innovation' and there were numerous papers concerning creativity at all key stages of the curriculum. There were also contributions concerning initial research studies supporting work with black ethnic minorities (Lewis et al, 2004) and pupils with behavioural, emotional and social difficulties in design and technology (Mitchell et al, 2004). It is important to keep up-to-date in your area of interest, if you want to be sure of making original contributions.

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Prior art (literature reviews)

It is possible for new researchers to access past and current literature concerning their research interests through the major refereed publications of the field. Table 1 shows the key refereed publications concerning design and technology education research.

Publication	Period	Notes
Studies in Design Education, Craft and Technology	1968 - 1988	Established by the late Professor John Eggleston, it was initially entitled *Studies in Design Education and Craft* In 1988, the 21st anniversary publication *The Best of Craft, Design and Technology* reprinted the most formative articles from this period.
.. then …		
Design and Technology Teaching: a journal of new approaches	1989-1995	Relaunched to provide a forum for sharing and developing expertise in all the contributing areas of design and technology: art and design, business studies, CDT, home economics and information technology.
…then …		
The Journal of Design and Technology Education …	1996-2004	Relaunched with Professor Richard Kimbell as Editor, to specifically include research contributions (although they had always been part of DATA's professional journals, such as *Design and Technology Teaching*) in the search for a sound foundation for the design and technology.
…then…		
Design and Technology Education: an International Journal	From 2005	Relaunched as an international research journal with Dr Eddie Norman as Editor. All these journals were published by DATA and some papers from later issues can be downloaded by DATA members from: **http://www.data.org.uk**
The International Journal of Technology and Design Education	1991-1996	Established by the late Professor John Eggleston, and originally published by Trentham Books, Stoke-on-Trent, UK.
	1997-2004 and onwards	Published by Kluwer in The Netherlands and available by subscription at **http://journals.kluweronline.com**

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The Journal of Technology Education	1989-2004 and onwards	Published by the ITEA[5], the journal focuses on scholarly, philosophical and research articles and can be downloaded from **http://iteawww.org**
IDATER (The International Conference on Design and Technology Educational Research and Curriculum Development)	1988-2001	*IDATER* archive is available at Loughborough University's Design Education Research Group website **http://www.lboro.ac.uk/idater**
… now *IDATER-ON-LINE*	… and onwards as a virtual conference	The first on-line conference runs from 2004-2005 and concerns the role of the Internet in teaching and learning in design and technology and science education.
DATA's International Research Conferences	2002-2004 and onwards	DATA held a special Millennium international research conference in 2000, and began its series of international research conferences in 2002 following the decision to take IDATER on-line. Recent papers are available to DATA members only and can be downloaded from: **http://www.data.org.uk**
CRIPT (The Centre for Research in Primary Technology) Conferences	1997-2005 and onwards	These international conferences are held biennially at the University of Central England and concern both research and curriculum development in primary design and technology. A conference book of the papers submitted is published on each occasion. 2005 will be the 5th conference in the series. **http://www.ed.uce.ac.uk/cript**/
PATT	1985-2005 and onwards	The *PATT* conferences are based in The Netherlands and PATT-15[6] will be the 20th anniversary conference, and the 15th international conference. These conferences are now organised in different locations around the world. The proceedings are available to download from **http://www.iteawww.org/D4c.html**

Table 1. Refereed publications concerning design and technology education research.

RESEARCH

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The select bibliography by Roberts (1991) includes many key publications, but there have been some additional books published more recently concerning design and technology education research that provide further overviews e.g:

• *Teaching and Learning Design and Technology: a guide to recent research and its applications* (Eggleston, 2000)
Engineering Council (UK) publications
• *Interaction: the relationship between science and design and technology in the secondary school curriculum* (Barlex and Pitt, 2000)
• *Design and Technology in a Knowledge Economy* (Kimbell and Perry, 2001)
• *The Continuum of Design Education for Engineering* (Harrison, 2001)
Open University (UK) publications
• *Understanding Practice in Design and Technology* (Kimbell, Stables and Green, 1996)
• *Technology's Challenge to Science Education: cathedral, quarry or company store?* (Layton, 1993)
• *Teaching Design and Technology* (Eggleston, 1992, second edition, 1996)
• *Shaping Concepts of Technology: from philosophical perspective to mental images* (Vries and Tamir, 1997)

The UK's National Association of Design Education (NADE) also publishes a journal. It has its origins in the 1970s, and at its peak published four issues in each year, although it now only appears occasionally. It can be found in some university libraries.

Publishing
Part of the funding of an academic department in a UK university depends on the external assessment of its research performance, (the RAE or Research Assessment Exercise, the next of which is due in 2008). In order for academic staff to contribute to their department's profile, it is essential that they publish their research. Teaching and research have also traditionally been seen as mutually supporting activities in universities, although that vision might be changing. However it would be hoped that academic staff would want to publish their contribution in order to participate in the on-going conversation. Such participation will bring external acknowledgement of their work, which will have probably been largely funded through their department. New researchers might begin by contributing to on-line conferences or presenting a poster at a 'real' conference, before deciding to progress to publishing conference and journal articles.

ITE Induction Progamme
The ITE (Initial Teacher Education) Induction Programme is being managed by DATA and funded by the UK's Teacher Training Agency (TTA). It aims to support new lecturers in design and technology education in becoming involved in research and it was decided to focus on three key areas:

• This keynote address for the induction meeting.
• Three new publications, published jointly by DATA and Loughborough University's Design Education Research Group:
  Readings in Design Education about fundamental issues discussed in the early years and to which researchers are returning, e.g: 'What is design? What makes designing possible?' These are questions to which we have come to believe we have answers, but do we? These readings have been edited by Professor Bruce Archer, Professor Ken Baynes and Professor Phil Roberts (available June 2005).
  Designerly Activity and Higher Degrees fundamental advice about research and research supervision from one of the foremost authorities in the design research, Professor Bruce Archer (available December 2004)
  Design and Democracy a key issue for the future. Why is it essential for everyone to study design in a democracy? This debate has been won and lost several times over the decades and is discussed in a book by Professor Ken Baynes (available March 2005).
• Development of web-based resources on DATA's website in order to make some of the papers from the international research conferences and the Journal of Design and Technology Education more readily available.

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Why these three publications?

Readings in Design Education
In the 1970s the debate about the nature of designing was fresh, new and exciting.   When writing about the nature of design problems and their resolution in 1979, Archer and Roberts put the general position as follows:

> *Design problems are described as 'ill-defined' because there is no way of arriving at a provision description merely by the reduction, transformation or optimisation of the data in the requirement specification. By the same token, it is rarely possible to determine whether or not the finished design is 'the correct'. 'the only' or 'a necessary' answer to the requirements. It must usually be possible, of course, to establish whether or not the design is a 'proper' or 'an acceptable' answer to the requirements. It may or may not always be possible to judge whether or not one 'proper' answer to the requirements is better or worse than some other 'proper' answer. Where such doubts do NOT exist, the problem is not 'ill-defined' and might therefore have been resolvable by scientific or mathematical methods rather than designerly methods. Most real-world problems encountered by most people are 'ill-defined'. (55)*

Hence, there was an emerging recognition that designing was addressing ill-defined or wicked problems, and, at that time at least, many of the consequences of that reality were well understood.   However, as the years have gone by, this recognition seems to have diminished. In 1984 a reader was published by the Open University, *Man-made Futures*, which contained an article written by Rittel and Webber in 1973. In this article they described ten characteristics of wicked (ill-defined) problems. One of these characteristics is that 'there is no definitive formulation of a wicked problem' (Rittel and Webber: 273). In discussing this proposition they write as follows:

> *To find the problem is the same thing as finding the solution; the problem can't be defined until the solution has been found. The formulation of the wicked problem is the problem! The process of formulating the problem and of conceiving a solution (or resolution) are identical, since every specification of the problem is a specification of the direction in which a treatment is considered. (ibid: 273-274)*

So, designing can only progress through modelling, and in educational terms 'learning' can only occur whilst 'doing'. Evidently, linear models of designing showing a number of stages should have been non-starters. You cannot complete your research and then carry out the designing, because until you start designing, you do not know what you want to find out. And there are additional complications, which are indicated in Figures 3 and 4. These models of designing are familiar enough, but their implications are often either forgotten or overlooked.   Figure 3 illustrates Pugh's plates, i.e that design problems have sub-problems each of which can be more or less defined. Figure 4 shows that the nature of design problems changes as designing progresses. So methods or strategies that might be appropriate at the start of a project might be entirely inappropriate in the later stages.
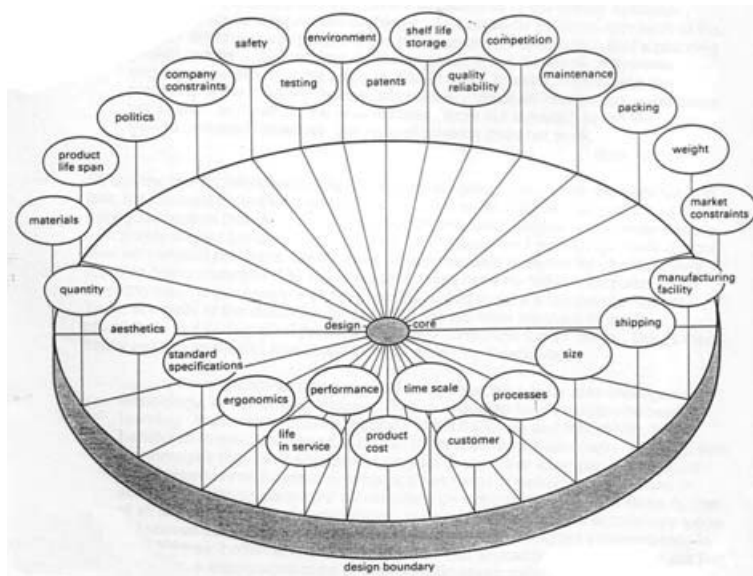
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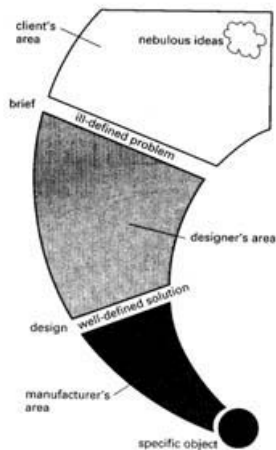**Figure 3. Pugh's Plates - the elements of a design specification (Cooke et al, 1984:9)**

Figure 4. The convergent nature of the design process (Cross, 1983:11)

Linear models, or 'models with stages' can only be descriptors after the event. They are assessment models, not models of designing as it takes place. Many curriculum developments have been built on some form of linear model, and what are the implications of having a model of teaching and learning based on an assessment model? Researchers have looked for evidence of a 'design process' (e.g. Welch, 1998 and Welch et al, 2000) and

demonstrated that this is not the way that children naturally set about designing. From a theoretical perspective, it would have been somewhat surprising if any evidence of a 'design process' had been found. Recent research from Israel has demonstrated that there it is better to teach children about designing by teaching them a functional approach rather than a structural (process-based) approach (Dagan and Mioduser, 2004).

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Researchers are also beginning to document the damage associated with such naïve approaches as linear models of designing (e.g. Murphy and McCormick,1997; Mawson, 2003), as well as revisiting the radical nature of Rittel and Webber's propositions concerning wicked problems (Coyne, 2004).

Looking back to a time before linear models of designing did not have the hold they have today on much of the subject area, puts some of the issues in a sharper perspective. Linear design models were themselves a product of the design science debates that took place in higher education in the 1970s, but their emergence was far from unchallenged. There is a sense in which some of those responsible for the development of design and technology have been consistently 'backing the wrong horse', and despite all the gathering research evidence and on-going theoretical arguments indicating the lack of wisdom in such choices, the temptation seems to remain overwhelming. It is refreshing to read authors were writing about these issues in more fluid times.

Designerly Activity and Higher Degrees
New researchers need guidance, and who better to provide that guidance than Professor Bruce Archer, who is one of the leading authorities on design research. Academic staff at Loughborough University were fortunate that Bruce Archer agreed to give a series of seminars concerning research as part of the staff development seminars in the mid-1990s. These seminars went beyond guidance concerning the general approach, which had been covered in his keynote address to IDATER91 and looked at detailed matters like the nature of research evidence, the supervision of research and writing a thesis. They covered the following seven topics:

- The nature and purpose of undergraduate design education in Britain.
- The nature and purpose of higher degrees and research degrees.
- The science tradition of research.
- The humanities tradition of research.

- Action research: research through art action, research through design action.
- A characteristic project trajectory in academic research.
- Supervision and examination of research degrees.

Archer discusses the science and humanities traditions of research and then action research, which is the key mode of enquiry in design and technology education:

All the normal rules governing research practice apply to action research. It must be knowledge directed. It must be calculated to produce new knowledge, or be intended to test, and maybe refute, existing knowledge. It must be systematically conducted. The chief questions to be addressed by the research must be unambiguously expressed. The methods of enquiry and analysis must be transparent. The data employed, and the observations made, must be fully and honestly recorded. And the whole must be exposed to critical examination by others.

However, in one important respect, action research is different from the other categories of research activity. Most other research is planned and conducted in such a way as not to contaminate the phenomenon under investigation. The investigator tries not to interfere with the situation, or to influence the forces at work within it. He or she tries to ensure that personal values and expectations do not affect either observations or conclusions. In action research, however, the investigator is explicitly taking action in and on the real world in order to devise or test or shed light upon something. Sometimes, notably in educational and medical research, the investigator is a participant in the human situation in which the action intervenes. In such circumstances, it is impossible to conduct the investigation on a value-free basis. Consequently, it is essential good practice for the action research investigator to make clear precisely what the intervention was, and exactly what theoretical, ideological

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and ethical position the investigator took up when making the intervention, observations and judgements. (43-44)

On a personal level, the research programme which led to the award of my PhD was an action research programme. When I joined the Department of Design and Technology at Loughborough University in 1984, the degree programmes were undergoing a period of change as they were at other universities in the UK. This is explained by Archer as follows:

(The economic recession)
There was another force precipitating change. The worldwide economic recession of the 1980s hit Britain rather early. There were bankruptcies and unemployment on a massive scale. Many manufacturing industries, already reeling from price competition and design innovation from Japan and the Pacific Rim, collapsed. International monopolies gained control of the design, manufacture and marketing of many classes of products. Whilst many of these industrial groups employed British design groups as product and advertising design consultants, there was a sudden drop in the demand for traditionally trained engineering graduates. Where small/medium sized companies were surviving, their need was not for specialist engineers, but for individuals with a range of skills, capable of dealing equally with research, concept design, styling, detail design and preparation for production …

(Product design … collaboration)
In 1989, when the former polytechnics were upgraded to become new universities, several of them possessed well-established and academically respected departments of industrial design, as well as departments of engineering. In most of these cases, the two departments were already collaborating by contributing instructors or learning modules to each other's courses. Inevitably, in the reorganisation of the new universities, the common interests of such pairs of departments had to be recognised, and in some cases industrial design-based product

design courses and engineering-based product design courses were regrouped to share common facilities. Studio or project based courses of the type familiar to art and design faculties were more widely introduced for the instruction of engineering designers. Other universities who had not previously taught engineering design at all, began to introduce engineering product design courses to their programmes. In 1989, there were fewer than ten university courses on engineering product design. By 1994, there were more than 200, some of them producing graduates with aesthetic sensibilities and communication skills fully comparable with those seen in graduates of schools of art and design. In an important sense, tertiary education is catching up with the revolution in design and technology that has been fought for in primary and secondary education. (ibid:13)

So the relationship of technology and designing was a fundamental aspect of the development of the Department of Design and Technology at Loughborough University in the 1980s and 1990s. This issue was also a fundamental aspect of the emergence in the UK of the common core A/AS-level syllabuses at 16+ in the same period. (These have since been replaced by the AS/A2 syllabuses, but had been the focus of some of my later experience in secondary education.) It was therefore a natural, if not inevitable, research agenda, given the symbiotic relationship expected between teaching and research. The PhD was awarded through published work, which enabled me to meet the publication requirements of my department during the years in which the research was being carried out. Again this is perhaps, the natural, if not inevitable route to a PhD if you have been appointed to an academic lecturing post on the basis of other equivalent experience. The PhD research was founded on the positions developed by Archer et al at the RCA[7] concerning the nature of design and designing. My research efforts were thus making a local contribution, but were founded within a wider discipline. A fuller account of the emergence of

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this research agenda, and the polymer acoustic guitar as a case study, can be found in Norman et al (2004).

Design and Democracy

If the relationship of knowledge and designing was one of the major unresolved issues of the 1990s, then the relationship of design and democracy is sure to be of comparable importance in the new millennium. Why should students be studying design and designing? This debate has been ably bought to the forefront of the international research agenda by Keirl, firstly at IDATER in 1999 and more recently at DATA's international conference in 2004. Professor Ken Baynes's forthcoming publication introduces the topic as follows:

Designers and writers on design frequently offer two very familiar interpretations of the essence of the activity:
that it is to serve human needs;
and
that it is about solving problems.

This presents design in a very favourable light. It suggests that designers are at the forefront of developing a benign and socially responsible material world. It also suggests that designers are largely able to set their own agenda: that designers can ensure that in their practice they actually serve human needs and solve problems that need solving.

In this publication I want to explore a very different perspective. If, in fact, contemporary design serves human needs, which needs does it actually succeed in satisfying? If it solves problems, whose problems are they? These questions arise and demand an answer because it is quite evident that the products of design activity – intended to serve human needs and solve problems – are themselves problematic. (7)

The discussion of these issues is pursued within a framework which embraces four perspectives.

The four perspectives are as follows:

Wealth
This perspective views design's role in society through the lens of growing wealth and professional specialization resulting from the division of labour in nineteenth century industry.

Products
This perspective explores the explosion in the manufacture of products and the nature of commodification in advanced capitalist economies and the role that is allocated to design in helping to forward the process of commodification.

Alternatives
Here the aim is to identify the nature of some critiques of design's support for a market economy and to characterise alternatives. Do any alternatives appear viable? Can the environmental problems facing the world be solved by an ameliorative strategy or is revolution required? Do designers have an identifiable role?

Participation
This perspective starts from a consideration of democracy and discusses how far participation is a reality in design decision-making. It looks at different models of management and identifies the design profession's stake in specialization. It describes the nature of the design education 'movement' and the radical ambitions of its approach.

A final section summarises some conclusions that may be drawn from these speculations. (13)

These matters will lie at the heart the development of design and technology in the early part of the twenty-first century, and can valuably be added to the research topics which need to be urgently addressed.

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Concluding remarks

So, in this keynote address some of the factors which lead to a strong research base have been discussed.

- The need for the deconstruction and reconstruction of the conceptual basis of design and technology as a subject in order to understand the context for current issues and debates.
- Securing and making accessible the records of the work of past researchers in order to support such analysis.
- Establishing a strong framework with both journals and conferences facilitating the on-going international conversations that will generate progress.
- Ensuring that new researchers are supported in establishing their place within this framework, for example, through DATA's ITE induction programme.

Design and technology education research must seek out those fundamental characteristics of humans that drive the international development of the subject. Those researches might well lead to greater understanding of human evolution itself, particularly in relation to cognition and creativity. The subject must be open to research progress in other disciplines, such as psychology, where the study of human intelligence and brain research could help in furthering understanding of design intelligence and capabability. Researchers must also explore the role played by design in the evolution of societies, in particular democratic societies. Much work and exciting times lie ahead.

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References

Archer, L B (2004), *Designerly Activity and Higher Degrees*, DATA: Wellesbourne.

Archer B and P.H Roberts (1979), 'Design and Technological Awareness in Education' in *Studies in Design Education Craft and Technology*, 12, 1.

Archer B, Baynes K and P Roberts (1992), *The Nature of Research into Design and Technology Education*, Department of Design and Technology, Loughborough University: Loughborough.

Barlex D (2003), *Creativity in Crisis? Design and Technology at KS3 and KS4*, DATA and The Nuffield Foundation: Wellesbourne.

Barlex D and J Pitt (2000), *Interaction: the relationship between science and design and technology in the secondary school curriculum*, Engineering Council: London.

Cooke P, Corbett J, Pugh S and D Weightman (1984), *A Guide to Design for Production*, Institute of Production Engineers.

Cross N et al (1983), *A Review of Design: design processes and products*, Open University Press: Milton Keynes.

Coyne R (2005), 'Wicked Problems Revisited' in *Design Studies*, 26, 1, 5-17

Dagan O and D Mioduser (2004), 'Do We Have an Alternative Methodology for Teaching Design' in Norman, E.W.L et al (eds) *Creativity and Innovation: DATA International Research Conference 2004*, 21-28

Daley J (1984), 'Design Creativity and the Understanding of Objects', in N Cross (ed), *Developments in Design Methodology*, John Wiley.

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Developing a Strong Research-Base

Dakers J (2003), 'The Introduction of Practical Craft Skills into the Scottish Technology Curriculum: a new beginning or the beginning of the end' in Norman, E.W.L et al (eds) *Design Matters: DATA International Research Conference 2003*, 23-27

Dasgupta, S (1996), *Technology and Creativity*, Oxford University Press: New York

DES (Department of Education and Science) and Welsh Office (1988), *National Curriculum Design and Technology Working Group Interim Report*, DES and Welsh Office: London.

Doyle M (2004), 'The Evolution of Technicity: whence creativity and innovation? in Norman, E.W.L et al (eds) *Creativity and Innovation: DATA International Research Conference 2004*, 67-72.

Eggleston J (1996), *Teaching Design and Technology* 2nd edn, Open University: Buckingham.

Eggleston J (2000), *Teaching and Learning Design and Technology: a guide to recent research and is applications*, Continuum: London and New York.

Gibbons M, Limoges C, Notwoty H, Schwatzman S, Scot P and M Trow (1994), *The New Production of Knowledge*, Sage: London.

Hargreaves D (1998), *Creative Professionalism: the role of teachers in the knowledge society*, Demos: London.

Harris W and V Wilson (2003a), *Designs on the Curriculum? A review of literature on the impact of design and technology in schools in England*, DfES: London.

Harris, W and V Wilson (2003b), 'Designs on the Curriculum? A review of literature on the impact of design and technology in schools in England', *DfES research brief no 401*, DfES: London.

Harrison, G (2001), *The Continuum of Design Education for Engineering*, Engineering Council: London.

Hicks, G (1982), *Understanding Design and Technology*, Assessment of Performance Unit.

Keirl, S (1999), 'As if democracy mattered … design, technology and citizenship or 'living with the temperamental elephant'' in Norman E W L and Roberts P H (eds) (2001), *Design and Technology Educational Research and Curriculum Development: The Emerging International Research Agenda*, Department of Design and Technology, Loughborough University: Loughborough.

Keirl, S (2004), 'Creativity, innovation and life in the lily-pond: nurturing the design and technology family while keeping the alligators fed' in *The Journal of Design and Technology Education*, 9, 3, 145-160.

Kimbell, R, Stables K and R, Green (1996), *Understanding Practice in Design and Technology*, Open University: Buckingham.

Kimbell, R and D Perry (2001), *Design and Technology in a Knowledge Economy*, Engineering Council: London.

Kimbell, R (2003), 'Reflections on the DATA Conference 'Paradigm' Debate' in *The Journal of Design and Technology Education*, 8, 1, 12-17

Layton, D (1993), *Technology's Challenge to Science Education: cathedral, quarry or company store?* Open University Press: Buckingham.

Lewis T, Lee J, Ross P, Dein J and J Dawson (2004), 'D&T Making a Difference in Black Ethnic Minority Education: the Sheffield LEA ICSYS partnership' in Norman, E.W.L et al (eds) *Creativity and Innovation: DATA International Research Conference 2004*, 121-128.

Mawson, B (2003), 'Beyond 'the design process': an alternative pedagogy for technology education' in *International Journal of Technology and Design Education*, 13, 117-128

Murphy, P and R McCormick (1997), 'Problem Solving in Science and Technology Education', in *Research in Science Education*, 27, 3, 461-481.

Developing a Strong Research-Base

McCormick, R (1999), 'Capability Lost and Found? The Maurice Brown Memorial Lecture in *The Journal of Design and Technology Education*, 4, 1, 5-13.

Norman, E (1998), 'The Nature of Technology for Design' in *International Journal of Technology and Design Education*, 8, 67-87

Norman E W L and P H Roberts (eds) (2001), *Design and Technology Educational Research and Curriculum Development: The Emerging International Research Agenda*, Department of Design and Technology, Loughborough University: Loughborough.

Norman, E W L, Pedgley O F and R L Coles (2004), 'Design Decision-Making and Materials: research agendas and gathering evidence' in *The Journal of Design and Technology Education*, 7, 2,133-141

Pugh, S (1990), *Total Design: integrated methods for successful product engineering*, Addison-Wesley: Wokingham.

Rittel, H W J and M M Webber (1974), 'Wicked Problems' in Cross, N et al (eds) *Man-made Futures: readings in society, technology and design*, Hutchinson Educational/Open University Press: London 272-280

Vries, M J de and Tamir A (1997), *Shaping Concepts of Technology: from philosophical perspective to mental images*, Kluwer Academic Publishers: Dordrecht.

Vries, M J de (2003), 'Design Matters, and So Does Philosophy of Design' in *The Journal of Design and Technology Education*, 8,3,150-153

Welch, M (1998), 'Students' Use of Three-Dimensional Modelling While Designing and Making a Solution to a Technological Problem' in *International Journal of Technology and Design Education*, 8, 241-260

Welch, M, Barlex, D and H S Lim (2000), 'Sketching: friend or foe to the novice designer' in *International Journal of Technology and Design Education*, 10, 125-148

Williams, I (2004), 'Strategies to Support Teaching and Learning Being Developed in Curriculum Development and Assessment Research' in Norman, E.W.L et al (eds) *Creativity and Innovation: DATA International Research Conference 2004*.

Footnotes
1 QCA/NESTA are the Qualifications and Curriculum Authority and the National Endowment for Science, Technology and the Arts, both UK organisations
2 DATA is the Design and Technology Association in the UK
3 DfES is the UK's Department for Education and Skills
4 IDATER is the International Conference on Design and Technology Educational Research and Curriculum Development which was held annually at Loughborough University in the UK between 1988 and 2001. It is now an online conference at http://www.lboro.ac.uk/idater/.
5 ITEA is the International Technology Education Association in the US.
6 PATT stands for Pupils' Attitudes towards Technology, which was the initial focus of these conferences, but this has since broadened to include all aspects of design and technology education.
7 RCA is the Royal College of Art which was home to the Design Education Research Unit in the 1970s and 1980s. This was initially headed by Bruce Archer, and later by Phil Roberts.