Designs on the Curriculum?
A review of the literature on the impact of Design and Technology in schools in England

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1. Introduction

The Department for Education and Skills (DfES) commissioned the Scottish Council for Research in Education to review the literature on the impact of Design and Technology (D & T) in schools. The review was conducted between August and November 2002. It draws mainly on UK literature published over the past decade. Much has been written about the subject of D & T by the community of practice, but little research-based evidence has emerged from the review.

2. Aims and findings

The overarching aim was to review the literature on Design and Technology. A summary of the questions addressed during this review and the main findings are presented below. Overall the searches reveal a subject that has come a long way in the twelve years since its inception. Many articles enthuse about what D & T can offer students; unfortunately few test these theories. Much of the research literature available is based upon very small-scale case studies and concentrates on a narrow area of research interests.

3. The concept of D & T

3.1 What are the different meanings and usages of D & T?

A number of different meanings emerge from the literature but most agree that Design and Technology:

- is a deliberately interdisciplinary subject that has its own distinctive non-verbal ways of thinking including use of imagination and ‘imaging’
- combines both ‘design’ and ‘technology’ but is broader than both
- encourages pupils to develop the capability and value judgements to operate effectively and creatively in the made world
- focuses on designing and making activities, and developing technological ‘capability’ for all pupils
- involves the use of cognitive modelling and the inter-relationship between modelling ideas in the mind and modelling ideas in reality, ie ‘thought in action’
- combines knowledge and motivation to enable pupils to intervene creatively in the world to ‘improve’ it.

3.2 What are the unique educational components of D & T?

Uniquely Design and Technology originally attempted to bring together craft, art and design, domestic science and business studies into one unified subject area.
Unsurprisingly, some of the components that advocates argue make D & T unique are also related to the different meanings and usages of the concept of D & T. Advocates suggest that Design and Technology is:

- a process-based subject, which builds pupils/students’ capability to operate effectively and creatively in the made world
- based upon ‘knowing how’ rather than about ‘knowing that’, ie ‘action knowledge’ rather than ‘propositional knowledge’
- a learning experience that is both academic and practical, ie an inter-relationship between conceptual knowledge and procedural knowledge
- empowering in that it is about creating change in the made world, about understanding processes and developing a capacity for bringing about changes
- a visionary activity; one that is about ‘what might be’ rather than ‘what is’, and therefore involves a special type of creative thinking that leads to the realisation of an artefact, system or environment
- purposeful in that it develops in response to perceived needs or opportunities and involves value judgements.

In addition, Design and Technology:

- draws on a richer range of learning styles than other curriculum subjects, mainly through project-based learning
- requires students to be creative but reflective problem solvers, either individually or in teams.

### 3.3 What are pupils’ curricular experiences of D & T?

**Activities**

A variety of stimulating tasks were described in the literature. The quality of activities on offer to pupils appears to have improved greatly over the past decade, but unfortunately, some suggest that the recent increased emphasis on literacy and numeracy in primary school work has made incursions into D & T time, so that sometimes activities lack sufficient depth or breadth. The use of ICT to support D & T is fairly extensive at both primary and secondary levels and Internet resources are proving useful for stimulating project ideas.

The National Curriculum for all Key Stages required that D & T activities include:

- developing, planning and communicating ideas
- working with tools, equipment, materials and components to make quality products
- evaluating processes and products
- knowledge and understanding of materials and components.
Plus, at Key Stages 3 and 4:

- knowledge and understanding of systems and control.

To meet these curricular requirements schools have provided a variety of experiences for pupils. In addition various programmes and initiatives are proving useful resources for teachers and students. These include the Nuffield D & T Project; the Design Museum’s Millennium Products; Sainsbury’s Taste of Success Food Awards Scheme; the Food Technology Website; School Nutrition Action Groups; The CAD/CAM in Schools Initiative; Marconi ECT; TEP, RCASTP and the Boots Family Evening Activities That Help Everyone Relax Socially (FEATHERS).

**Characteristics of pupils**

Since its inception, D & T has been a compulsory subject for all children from age 5 to 16. The DfES consultation paper *14-19: Extending opportunities, raising standards* proposes a new structure for the National Curriculum at Key Stage 4. Pupils will have a statutory entitlement of access to D & T but it will not be compulsory from age 14 upwards.

**Ethnicity:** There was very little information relating specifically to ethnicity of either pupils or teachers in the D & T literature. The QCA Respect Curriculum is, however, one example.

**English as Additional Language:** Some positive examples of working with refugee children or those with English as a second language were found. However, limited research findings suggest that teachers need to be sensitive to racial matters when setting tasks and working with particular materials within the D & T curriculum.

**Disability:** Literature relating to pupils with special educational needs within mainstream schooling was scant. (It should be noted that D & T provision in special schools was excluded from this review.) However, one small case study found that autistic children could develop their technological capability, with skilful teacher interventions.

**Gender:** There is a lack of current reliable and unequivocal evidence concerning gender issues relating either to pupils or teachers in the D & T literature. Evidence prior to the inception of D & T as a curricular subject indicates that subject choice was strongly gender differentiated. However, findings from the early 1990s show that sex disadvantage in technology education can work both ways depending on the activity.

- Tests requiring reflection favour girls, whereas active tasks favour boys.
- The performance of low-ability girls is fragile.
- Context is important, with girls excelling in people contexts and boys in industry contexts, whereas environment contexts are gender neutral.
- Context effects are greater for low-ability pupils.
- Girls outperform boys in all areas of communication.
During the early 1990s girls’ work in technology (especially construction) was inferior to that of boys. This was thought to relate to play with gender specific toys in pre-school years. Remedial measures have been tried to help compensate, with equivocal success. There is some evidence that gender stereotyping in D & T is decreasing. However, underachievement of boys in D & T (and other subjects) is becoming problematic. The D & T framework, assessment practices and teacher gender bias are influencing factors.

Types of provision experienced
Research on the types of provision experienced by pupils is scant, however, Ofsted Subject Reports from 1999 to 2001 show that:

- primary school D & T resources, accommodation and facilities need improvement
- over 20% of Secondary schools are failing to comply with the requirements of the National Curriculum for D & T
- recruitment of suitable D & T teachers is becoming problematic.

Teaching methods
The literature indicates a fairly limited amount of research on methods used by teachers of D & T. Nevertheless, papers in D & T journals highlight the potential of D & T to develop cognitive skills through a variety of different teaching methods.

- Good teacher attitudes and interactions with students are essential to developing technological capability in pupils. During projects, D & T teachers work with individual pupils, small groups and the whole class in different contexts to facilitate opportunities for pupils to learn a wide variety of skills and to reflect on their own work.
- Different organisational approaches can be used to good effect, eg working in concentrated periods or over a longer period of time. Out of school expertise can also be used to aid student motivation.
- Structured learning in D & T helps to develop problem solving, observation and collaboration among pupils.

However, despite these positive examples, there is some evidence of weak teaching practices, such as unclear task setting and giving the same work to all pupils. Also some teachers are coaching pupils purely to pass assessment stages, rather than developing wider D & T objectives.

Pupil results
Statistics for the current year are provisional due to marking anomalies. Figures have therefore been derived from a variety of sources.
GCSE
- There was a slight rise (1%) in the proportion of D & T students gaining grades A*–C this year.
- Girls continue to outperform boys in all D & T subject elements.

GCSE short course
- There was a continuing upward trend in the proportion of both sexes awarded grade C or above.
- Girls outperform boys at higher grades (39% of boys compared to 61% of girls achieve grades A*–C).
- Fewer pupils received ungraded awards in D & T this year (2002) than in 2001.

Post-16 D & T
- A2 results have again improved, especially at the highest grades.

D & T trends 1992-2001
- There was a large rise in numbers of candidates taking D & T A-level and GCSE full and short courses.
- There was a steady increase in the percentage of pupils achieving grades A*–C in A-level and GCSE full and short course D & T throughout the decade.
- Unclassified grades have declined for D & T A-level and GCSE short courses.

Links to professional design activity/local business
Ofsted inspectors report that schools they visited had developed professional design activities and established links with local business. Most D & T students were confident and creative users of complex equipment; in particular CAD/CAM and the skilled use of industrial standard software. More teachers used experts from outside school to act as consultants or to support the work in other ways, such as providing independent testing and evaluation of the products pupils have made. In particular, some primary schools also utilised their local Education and Business Partnership Centres to enrich pupil access to resources not available in schools. Extra-curricular activities were often of a very high standard and used by an increasing proportion of schools to provide support and challenge for pupils.

Vocational training (GNVQs)
There is fairly strong evidence that vocational training varies widely in approaches to knowledge, skills and understanding and provides different student experiences. The surprising degree of diversity that exists is not necessarily detrimental as it relates to prior experiences and curricular orientations of teachers, and capitalises on their strengths. However, national qualifications should have comparable standards across courses and centres, and
the revised assessment model introduced in September 2000 was designed to improve consistency of standards, assessment, and manageability for teachers. This should gradually improve the situation.

**Progression post-14 and post-16**

The DfES consultation paper *14-19: Extending opportunities, raising standards* proposes a more flexible curriculum for 14 to 19-year-olds. Pupils will have a statutory entitlement of access to D & T but it will not be compulsory from age 14 upwards. From September 2002, the Part One, Foundation and Intermediate GNVQs were replaced with eight new vocational GCSEs. Two main points emerge from existing evidence on progress at post-14 level.

- At Key Stage 4 there is greater use of ICT, CAD/CAM equipment and techniques.
- Design work remains weak. Inspectors report that many pupils do not develop a sufficiently detailed design specification that will provide them with the required information for further development and evaluation. This affects the designs and resulting products.

**3.4 What is the effect of including D & T as part of the National Curriculum?**

The introduction of D & T into the National Curriculum was not based on empirical evidence. Following its inception, many problems were experienced, but a series of revisions of the D & T curriculum have resulted in more understanding of what can be achieved. Some of the effects of including D & T in the National Curriculum were identified in the literature.

**Key Skills development:** Although most accept that the D & T has the potential to develop Key Skills, we found scant evidence of actual improvement relating directly to D & T.

**Cognitive development:** The consensus is that D & T does provide opportunities for pupils to develop high order thinking skills and problem solving skills, but opinion is divided on which activities contribute most, and which children gain most benefit. However, most researchers agree that D & T enhances ‘conscious awareness’ of thought processes. Interactions with teachers and peers, in conjunction with active processes inherent in D & T activities, enable pupils to represent, analyse and reconstruct knowledge to create a product. One study suggests that the best collaborative work results from the pairing of intellectually similar students. However, overemphasis on product outcomes and ‘coaching’ for public examinations hinders cognitive development.

**Raising standards of achievement:** It has not been possible to determine what effects have been due to D & T, however, some improvements in D & T were noted.

- **Literacy:** The development of a technical vocabulary is essential for effective participation in D & T, but observational studies suggest that the use of technical vocabulary should be delayed until secondary school.
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- **Numeracy**: Evidence of the effect of D & T on numeracy was not forthcoming, but D & T has obvious links with mathematics eg for measurement, calculation and data analysis.

- **Key Stage tests, GCSE, A-level and GNVQ**: We found little evidence of the possible impact of D & T on other subjects in Key Stage tests, GCSE, A-level or GNVQ results. However, achievement in D & T is rising at a rate well above the average of all subjects.

**Enhancing attendance patterns**

There was a paucity of information on truancy and attendance related directly to D & T. Incidental references to attendance patterns were conflicting; eg D & T would appear to have a positive effect on truancy, yet on the other hand, some KS4 pupils have become disaffected.

**Tackling issues of social exclusion**

There were few research studies related specifically to D & T and social inclusion. However some schools are supporting pupils with behavioural problems, learning difficulties and exclusion by virtue of ethnicity.

**Cross-curricular learning**

There is evidence to confirm that cross-curricular learning is fundamental to D & T activity in primary schools. However, effects of such learning are less clear. Good cross-curricular links have been made with mathematics, ICT, art, and science, but may not be sufficiently exploited. In addition, doubt has been cast on children’s ability to transfer knowledge from one context to another.

**3.5 How can D & T be delivered economically and effectively?**

Numerous researchers have highlighted the importance of up-to-date accommodation, equipment and materials to the effective delivery of D & T. There are some examples in the literature of how the subject can be economically and effectively resourced.

- Support from senior staff is a key factor in improving standards in D & T. Similarly, good management of resources is important in effective delivery.

- The effectiveness of D & T INSET courses can be improved if teachers produce action plans.

- The Internet is proving an economic and effective way to deliver projects and INSET to teachers and students (eg the Marconi ECT; the DATA website).

- Collaborative relationships with local businesses and industry, or local Education Business Partnerships (now EBLOs) can help schools access expensive CAD/CAD equipment.
• Teachers clearly have a central role to play in effective delivery and should encourage students to be creative risk takers, rather than principally preparing them to pass examinations.

3.6 How can D & T learning (and teaching) be enhanced?
A number of ways of enhancing D & T learning and teaching were identified in the literature. The consensus is that D & T requires:

Resources
• a clear strategy and direction, collaborative effort between DfES, its agencies, industry, LEAs and DATA, supported by good publicity and sufficient resources
• adequate accommodation, including teaching and storage facilities
• effective access to ICT, including lunchtime or after-school activities
• high-tech equipment, software and success in training teachers how to use them
• emphasis on a wide range of modelling techniques in designing as it is cognitive processing which is important in design activity in D & T.

Up-dating
In order to keep abreast of new technology, pupils need to have:
• access to up-to-date materials, ICT and the Internet
• easy access (to new materials and technology), rather than working with recycled materials
• relevant new information.

Where schools are having great difficulties in remaining up to date, they should try to increase opportunities for appropriate INSET, and teacher training in general, and also improve access to relevant new materials, and publications.

Curriculum content
There was very little research evidence relating to this topic. Some researchers believe that employers want ‘skills and attitudes such as enterprise, innovation, teamwork, creativity and flexibility’, all of which are associated with the concept of D & T. And the dearth of suitably skilled people entering the electronics industry led Marconi to fund training courses (The Marconi ECT Project) for teachers to improve their electronics expertise.

Specific mention was made of the way that D & T is being practised in schools, which may not be developing pupils’ creativity sufficiently. Designing tasks are unsatisfactory in many schools. Teachers often restrict students to work that will result in a safe outcome in assessment or examination due to current curriculum requirements. In addition, the variety in GCSE and 16+ courses has been criticised. Higher Education and employers need to make effective use of prior learning and therefore must know exactly what has been learnt in D & T.
Teaching methods

Research literature relating to teaching methods employed by teachers of D & T covered a variety of topics. Although these studies provide insight into aspects of teaching D & T activities, one must interpret the findings with caution as many have been based on very small numbers. Most agree that effective teaching of D & T requires a very wide range of teaching methods. The interaction of teachers with individuals, groups and whole class activities is crucial in developing pupils’ technological capability. Very much is demanded of the good D & T teacher. Good planning is therefore essential.

- Good D & T teachers challenge children with problems set in real contexts; teach procedural skills selectively to develop appropriate skills and competences; and involve children in group discussions which aids design, reflection and evaluation of D & T tasks.
- Group work is valuable, especially during the early design stages but the best results were achieved from working in matched intellectual ability groups, so as not to disadvantage less able children.
- Teachers must not let products take precedence over design processes or problem solving.
- Methods of teaching are superior where teachers themselves have developed a deeper, personal understanding of the processes involved in designing; such teachers are more able to teach pupils how to design well, how to develop thinking skills, and how to represent this in an appropriate way.
- Structured learning is particularly valuable in D & T. For example, handling products helps pupil understand how products work and what they are made from, and develops a broader range of skills such as problem solving, observation and collaboration.
- Studies of collaborative learning suggest this may be a useful teaching method in D & T, but to date this has not been sufficiently employed.
- Cross curricular learning is a strong feature of D & T activity but to use this to good effect teachers need to have good co-ordination with other disciplines and should link knowledge learned in one temporally close to its application in another.

Teacher Training: Continuing Professional Development

As many primary staff still lack specialist knowledge more training or INSET is required. A shortage of specialist teachers is also problematic at secondary level, especially in food technology and for systems and control. Good staff development in D & T:

- recognises the teacher as an adult learner
- provides adequate time and funding to address the issue of updating subject knowledge
• meets the needs of teachers
• provides time for collaboration
• monitors the effects.

There is some evidence that teachers are not always able to put ideas learned in INSET into practice in schools and require more support from headteachers/INSET co-ordinators to implement and monitor their action plans.

3.7 What are the gaps in the research evidence?
Our general conclusion is that despite the number of references to D & T identified in the literature, few are research-based in terms of meeting peer-review standards. We recommend that the development of the D & T curriculum and learning and teaching would benefit from more funded and better quality research in D & T.

Specific issues which merit consideration are:
• Can a model of research for D & T, which includes ‘users’, be developed and funded?
• 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 development of higher level skills?
• How do good/effective teachers teach D & T, organise their classrooms, workshops, and equipment, and how do they 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 do employers in industry/business want from D & T and how can productive relationships with them be extended?
• Do up-to-date resources impact on pupils achievement?
• 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 curriculum at Key Stage 4.
1: Introduction

1.1 Background to the review

The role of Design and Technology in schools in England is changing. These changes were heralded by the Green Paper 14–19: Extending Opportunities, Raising Standards (Feb 2002, Cm 5342) which proposed that education and training of 14–19-year-olds should be delivered by a more flexible curriculum with a broad range of options. Design and Technology (D & T) will no longer be compulsory from age 14; but students will have a statutory entitlement to opt to study D & T subjects.1 It is anticipated that these changes will impact considerably on D & T provision in schools, but what exactly is D & T? How has it been taught in primary and secondary schools to date and what problems has it encountered being accepted and living up to the high expectations of its advocates? These are some of the themes which will run throughout this review of published literature which the Department of Education and Skills commissioned the Scottish Council for Research in Education (SCRE Centre) to undertake between August and November 2002.

1.2 Aims

The main aim of the review is to search for evidence on the impact of Design and Technology (D & T) on schools in England. In particular, the review concentrates on the contribution D & T has made to education since its inclusion in the National Curriculum in England and Wales. Thus, although the review is restricted to literature published since 1990, some relevant historical information is included. International comparisons are made where these are relevant.

Literature will be identified that helps to provide answers or highlight issues relating to the following research questions.

The concept of D & T

- What are the different meanings and usages of ‘D & T’?
- What are the unique educational components of D & T?
- What are pupils’ curricular experiences of D & T?

The effect of including D & T as part of the National Curriculum

- What has been the impact on skills, understanding, standards, attendance, take-up, social inclusion and cross-curricular learning?

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1 See Revised Guidance on Disapplication of the National Curriculum at Key Stage 4 for Specific Purposes under Section 363 of the Education Act 1996 (The Education (National Curriculum) (Exceptions at Key Stage 4) (England) Regulations 2000 (SI 2000 No.1140) were amended under (SI 2002/2048)).
The delivery of D & T

- What can be learnt from the way D & T is delivered?
- How can it be delivered economically and effectively?

Gaps in the research evidence

- In which areas is further research required to assist the development of the D & T curriculum and also teaching and learning?

1.3 Search methods

Many policy-makers now seek to ground their decisions on an evidential base, but what constitutes high quality evidence is far from obvious. As in previous SCRE reviews (eg Harlen & Malcolm, 1997), we have utilised the concept of ‘best evidence synthesis’ which Slavin (1987, 1990) applied to reviewing educational research. It requires the reviewer to identify criteria for determining good quality research and to place more emphasis on those studies which match the criteria than those which have identifiable shortcomings.

Other researchers have developed different approaches to identifying high quality evidence. For example, the Campbell Collaboration (Boruch et al, 1999) sets a premium on evidence generated from randomised field trials. As will become apparent in the review, few studies published on the impact of D & T in the National Curriculum can meet this strict criterion. We have therefore, included a number of small-scale studies and reports from Ofsted, which, although not meeting the quality criterion, do offer some insight into under-researched areas of the topic.

It is against this background that this current review should be placed and its limitations made explicit. First, this review was undertaken within a short timescale, which can hardly do justice to the volume of published work. Over one and a half thousand items were identified using a combination of ‘technology education’ and ‘design and technology’ key words (see Appendix 1). Second, although criteria were established, adherence to strict criteria for best evidence was frequently not possible. For example, there is a paucity of well-planned experimental studies in the UK, and the application of strict criteria would have left the review heavily dependent on international evidence – which is not always generalisable to the D & T provision in the UK. In addition, systematic review of international evidence was unrealistic given the timescale. Finally, some studies provide insufficient information upon which to judge the quality of evidence.

The criteria for inclusion of studies in this review were:

- papers published during the past twelve years
- studies relating to primary and secondary mainstream schooling
- studies of well-designed experimental interventions in D & T education
• papers published in peer-reviewed journals; and Government policy documents. Where these were not sufficient, relevant conference papers may have been included.

With guidance from the D & T Strategy Group, various institutions were approached during the period of the review exercise to elicit any relevant unpublished sources of information.

Key words applicable to this review process were used to search literature from educational databases (see Appendix 1). A set of broad key words was agreed with the Strategy Group and subsequently these words were reduced to match those best fitting the specific databases used. A series of searches of all relevant databases was undertaken. Where these proved unfruitful, free text searching was undertaken on an iterative basis using the original key words agreed with the Strategy Group.

1.4 Organisation of the review

This review is presented in seven sections, of which this, the introductory chapter is the first, and provides the outline aims, methodology and structure of the whole review.

Chapter 2 sets the recent history of Design and Technology as a National Curriculum subject in context. Subsequent chapters are organised according to the principal research questions.

Chapter 3 outlines the different meanings and usages of the concept of design and technology as defined by Statute and key figures in the development of D & T. It also points to the educational components that are uniquely or most strongly associated with this subject.

Chapter 4 explores pupils’ current curricular experiences of D & T.

Chapter 5 examines various factors to try to determine the effect of this subject on cognitive development, achievement, and particular social issues since the introduction of D & T to the curriculum.

Chapter 6 raises issues concerned with the effective delivery of D & T.

Finally, Chapter 7 deals with the gaps in the research evidence and suggests research topics which would contribute to the further development of the subject.
2: Introductory History

2.1 Summary

Two research questions were addressed in this section.

- What is the relevant history of Design and Technology?
- Which aspects of its development are unique?

The principal findings are summarised below.

- Design and Technology was included in the core National Curriculum in 1990.
- England and Wales were the first countries in the world to include the subject in the core curriculum.
- Uniquely, the Design and Technology curriculum attempted to bring together aspects of craft, design and technology, art and design, domestic science and business studies into one unified subject area.

2.2 Origins of Design and Technology

‘Design and technology’ was introduced into the National Curriculum as a distinct academic subject in 1990 (under the Technology in the National Curriculum Statutory Order, DES and Welsh Office, 1990). Some suggest that this was a response to Government recognition of the importance of technology to the British economy (Layton, 1995). However, most are agreed that little research evidence existed before the introduction of D & T into the curriculum on which to base decisions (eg DES/WO, 1988, Section 1.15; Penfold, 1988; Kimbell et al, 1996; Shield, 1996). Nevertheless, its associated ‘distinctive model of teaching and learning’ had been evolving over a few decades (eg Penfold, 1988; Kimbell et al, 1996; Kimbell & Perry, 2001). England and Wales were the first countries in the world to make technology education compulsory for all children between the ages of 5 and 16 (Education Act, 1988; Kimbell & Perry, 2001). This has been described as a ‘pivotal moment in history’.

Never before had it been an entitlement for all children to study technology; now it was … Never before had it been the least bit significant in the primary curriculum; now it was. Never before had the specialist subjects in the secondary school technology domain (craft, design and technology; home economics, art and design) been grouped and expected to provide a single coherent technology experience; now they were…It was a great moment.

(Kimbell, 1997, Ch 4, Assessing Technology)

Following its introduction into the National Curriculum, D & T went through a rapid rise in status over a relatively short time span. Paechter (1993) argues that this was achieved without significant involvement from those who would become the teachers of the new subject. Six revisions of the Statutory Order have taken place since 1990 leading to improvements in curriculum content and delivery. However researchers point out that the introduction of the new subject
into the curriculum was not without its teething troubles (Kimbell, 1997; Davies, 2000), nor critics (Smithers & Robinson, 1992). According to Kimbell and Perry (2001) part of the problem was that the 1990 Order for Technology had been based on best practice in a minority (5–10%) of schools. For the first five years, it is agreed that many teachers struggled to adjust to the new requirements until the introduction of the new revisions which gradually led to a broader understanding of the subject, with a consequent wider distribution of good practice.

Official documents show that The Education Reform Act (1988) established a framework within which all subjects were to be defined. In addition to the core subjects of English, mathematics and science, there were to be seven foundation subjects, one of which was technology. For each subject Attainment Targets were set, outlining areas within which pupils could develop and progress could be measured. Similarly, Programmes of Study (PoS) defined what was to be taught, ie ‘the essential matters, skills and processes which need to be covered by pupils at each stage of their education’ (DES, 1989 para 3.12). Progress was to be measured across four ‘key stages’ of compulsory schooling, ie infant (KS1), junior (KS2), 11–14 (KS3) and 14–16 years (KS4) with pupils being tested at ages 7, 11, 14 and 16.

Kimbell (1997) describes how assessment methods were devised by subject specific working groups set up by the Task Group on Assessment and Testing (TGAT). The Design and Technology Working Group advised on attainment targets and programmes of study for D & T. Representatives from science, craft, design, home economics, and business & vocations all contributed towards the new emerging subject and exerted influence on the Working Group (see Davies, 2000).

One of the main objectives of the 1988 Working Group was to establish technological ‘capability’ for all pupils. The Working group identified Craft, Design and Technology (CDT) (Penfold, 1988) as being a core component of the new D & T. Their interim report emphasised the importance of ‘design and make’ activities as central to the development of technological ‘capability’. Others point out that this issue of capability was not entirely novel but had been evolving over the previous few decades (Penfold 1988; Kimbell, 1991). The significant change in technology education that took place at this time was the shift in emphasis from ‘outcome’ to ‘process’ (Kimbell, 1997). Indeed, five out of six attainment targets for technology focussed on process (DES, 1988a) and these formed a ‘profile component’ of D & T capability.

As Kimbell (1997) points out much of the confusion teachers suffered initially following the introduction of D & T into the curriculum was related to the mismatch between the ‘Programmes of Study’ and ‘attainment targets’. Whereas ‘Programmes of Study’ outlined what teachers had to teach, teachers had to assess pupils using a different set of criteria that were set out in the ‘attainment targets’. This confusion over methods of assessment greatly increased the bureaucratic workload for teachers (Kimbell, 1997). In addition, others believe that the training for managing this was inadequate and this sudden lack of
content caused problems (Hendley & Lyle, 1996; Levinson et al, 1997; Davies 2000). In 1996, such was the confusion about the new subject of D & T, that The Design and Technology Association (DATA), in conjunction with the DfEE, issued an explanatory leaflet for parents and teachers (Barlex & Pitt, 2000). Despite these early difficulties D & T’s introduction into the National Curriculum remains an exemplar that the rest of the world has been following for guidance for the past decade (Kimbell et al, 1996; Kimbell & Perry, 2001).

Further revision of the National Curriculum at all Key Stages and in all subjects became statutory from August 2000, with minor exceptions including Key Stage 4 Programmes of Study for D & T. (This became statutory from August 2001.) The most recent revisions aimed to promote stability in schools and enable them to focus on raising standards of pupil attainment. Schools were given more flexibility to develop the curriculum to meet the needs of their pupils and local communities. The revised D & T Programmes of Study, in common with those in other subjects, sets out two distinct parts: the ‘knowledge, skills and understanding’ and ‘the breadth of study’ requirements. Some see the development of technology education as ‘the one truly revolutionary subject to enter the National Curriculum… Indeed it would not be an exaggeration to say that it was invented for the curriculum and has gone on to become part of the extended core’ (Graham, 1993). However, after a decade of experience since D & T entered the core curriculum, Davis (2000) concluded:

... the last 10 years have certainly been a ‘steep learning curve’ in the processes and pitfalls of introducing the world’s first universal technology curriculum. Despite the many false starts, much wasted paper and time, we are now closer to deciding as a society and profession what we want children to be able to do in the development of technological capability… Let us hope, with the current ‘squeezing’ of design and technology in the primary curriculum for England that all this effort has not been in vain!
3: The Concept of Design and Technology

3.1 Summary

Two questions are explored in this section.

- What are the different meanings and usages of the concept of D & T?
- What are the unique educational components of D & T?

The most common meanings and usages of D & T include the following elements.

- D & T is a deliberately interdisciplinary subject that has its own distinctive non-verbal ways of thought including use of imagination and ‘imaging’. It is a concept which combines both ‘design’ and ‘technology’ but is broader than both.
- D & T activities are carried out with definite purposes in mind, within specific constraints and requiring value judgements. It focuses on designing & making activities, and developing technological ‘capability’ in all pupils so they may operate effectively and creatively in the made world.
- The capacity for design involves cognitive modelling. The inter-relationship between modelling ideas in the mind and modelling ideas in reality is fundamental to capability in D & T and can be described as ‘thought in action’.
- D & T combines knowledge and motivation in a way that enables pupils to intervene creatively in the world to ‘improve’ it.

The unique educational components of D & T are identified as follows.

- D & T is a process-based subject. It develops capability to operate effectively and creatively in the made world, and is more about ‘knowing how’ than ‘knowing that’.
- D & T is both an academic and practical learning experience; with an inter-relationship between conceptual knowledge and procedural knowledge. It aims to be empowering, creative and visionary concerning ‘what might be’ rather than ‘what is’ which leads to the realisation of an artefact.
- D & T activity is purposeful in that it develops in response to perceived needs or opportunities and involves value judgements.
- D & T draws on a richer range of learning styles than other subjects do. Work is mostly project-based. Students work within constraints of time, cost and resources, deconstruct and manage the complexity of tasks and uncertainties inherent in their projects.
- D & T requires students to be creative problem solvers, working individually and in teams to develop and evaluate ideas relating to a product design.
3.2 The concept of D & T

In this section a range of meanings and usages of the term D & T have been selected to provide some insight into the essence of D & T. In her letter to the Secretary of State accompanying the Interim Report, the chairman of the National Curriculum D & T Working Group (DES/Welsh Office, 1988), Lady Parkes, explained that:

*Our* [the Working Group’s] *aim has been to develop an approach to design and technology which will enable pupils to achieve competence by engaging in a broad range of activities which are currently undertaken in a number of different school subjects.*

It is, therefore, not surprising that D & T has come to be acknowledged as a multidisciplinary subject with potential for cross-curricular activity. The Programme of Study (PoS) for D & T stated that pupils should be given opportunities to: ‘apply skills, knowledge and understanding from the Programmes of Study of other subjects, where appropriate, including art, mathematics and science’ (DfE/WO, 1995, p6). But this assumes that conceptual knowledge learned in one area of curriculum can be applied to another area, and that it is the same knowledge. Yet in 1995, as Levinson *et al*, (1997) note, there were no cross-references with the science curriculum. However, more recent PoS, including the current National Curriculum, link D & T with a range of other subjects including science, mathematics, art & design and ICT.

Others (Kimbell & Perry, 2001) suggest that D & T is ‘deliberately interdisciplinary’: ‘It is a creative, restive, itinerant, non-discipline’. The Working Group (1988) also stressed that the new subject should encompass more than just Technology:

*Our use of design and technology as a unitary concept … 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.*

(DES/WO 1988, para 1.6)

The special characteristic of D & T is that pupils learn the capability to operate effectively and creatively in the made world. D & T is an activity carried out with definite purposes in mind, within specific constraints and requiring value judgements at every stage. It has its own distinctive non-verbal ways of thought including use of imagination and ‘imaging’ (Summary 1.9–1.12).

(DES/WO 1988, Summary paras 1.9–1.12)

From the documentation it is clear that one of the central features of D & T is its focus on designing and making activities, and developing technological ‘capability’ for all pupils.

- Pupils are able to use existing artefacts and systems effectively.
- Pupils are able to make critical appraisals of the personal, social, economic and environmental implications of artefacts and systems.
The Concept of Design and Technology

- Pupils are able to improve and extend the uses of existing artefacts and systems.
- Pupils are able to design, make and appraise new artefacts and systems.
- Pupils are able to diagnose and rectify faults in artefacts and systems.

(DES, 1988a, paras 1.42-1.43)

Huxtable et al, (1991) identified three main concepts at the heart of D & T.

- What resources the activity (ie human, physical, financial or technical resources)?
- How is a D & T activity handled (eg processes, techniques and methods employed)?
- How/why people are linked to processes/resources?

They concluded that ‘capability’ can only be achieved when an inter-relationship occurs between these three concepts and that this delineates ‘ability’ from ‘capability’: ‘If the separate elements are fostered ability is developed, however where the concepts are developed in an inter-relational way, then capability is achieved’.

More recent descriptions of ‘capability’ have embellished and reiterated sentiments set down in the Working Group’s original report. For instance, Kimbell (1997) describes capability as ‘that combination of skills, knowledge and motivation that transcends understanding and enables pupils creatively to intervene in the world and ‘improve’ it’. He says that capability provides pupils with a bridge between what is and what might be. Thus pupils are expected to develop the capacity to identify things which need improving or creating in the world and in response, design and make something that will bring about the desired improvement (Kimbell et al, 1996; Kimbell, 1997). Moreover, the capacity for design should involve the use of cognitive modelling (Layton, 1995; Roberts, 1994). This inter-relationship between modelling ideas in the mind and modelling ideas in reality, described as ‘thought in action’ (Kimbell et al, 1991) is seen as fundamental to capability in D & T.

In addition, advocates describe a societal dimension to D & T, one that ‘entails critical reflection upon and appraisal of the social and economic results of design and technological activities beyond the school’ (DES/WO 1988 para 1.14). D & T is thought to require a breadth of understanding and social concern and a depth of knowledge and skill, together with a capability to identify shortcomings and take creative action to improve the made world (Kimbell & Perry, 2001).

Kimbell and Perry (2001) note that D & T is about ‘creating change in the made world; about understanding the processes of change and becoming capable in the exercise of change-making’. An explanatory leaflet issued by The Design and Technology Association (DATA, 1996) states that learning in D & T:

helps to prepare young people for living and working in a technological world. Children learn the technical understanding, design methods and
making skills needed to produce practical solutions to real problems. D & T stimulates intellectual and creative abilities and qualities of commitment and perseverance. It enables young people to relate personal experience to the work of commerce and industry, to understand how design and technology affects our lives, and contributes to the use and development of technology in our society through informed participation.

(Data & DfEE, 1996: 2, see Barlex and Pitt, 2000)

Others (Barlex & Pitt, 2000) argue that ‘the art of designing’ is intrinsic to the concept of technological activity. The Working Group (1988) cautioned against using the term ‘design process’ (para 1.27), and cited warnings outlined in the APU/DES report (HMSO, 1987) against any linear, rule-bound view of what the activity of designing entails.

Finally, although other subjects could be said to involve ‘process’, uniquely within technology education the process is said to define the discipline (DES, 1988; Kimbell, 1997: 46-47). The contexts in which the ‘process’ is associated are ‘our made world; our clothes, our food, our means of travel, our shelters, our communication systems’ (Kimbell & Perry, 2001).

3.3 What are the unique educational components of D & T?

Unsurprisingly, some of the factors which researchers claim make D & T unique are the same as those which relate to the different meanings and usages of the concept of D & T. Paechter (1993) points out that the sudden elevation of what had been a practical subject area for less academic pupils to the core curriculum was unique, especially for secondary schools. In addition, Hendley and Lyle (1996) identify the process-based nature of D & T’s curriculum as its most unusual feature. Kimbell (1997) has described this change in pupils’ learning as: ‘a move from receiving “hand-me-down” outcomes and truths to one in which we generate our own truths. The pupil is transformed from passive recipient into active participant. Not so much studying technology as being a technologist’ (p 47).

One of the questions addressed by the Working Group in 1988 was: What is it that pupils can learn from D & T activities which can be learnt in no other way? Their reply was:

*in its most general form, the answer to this question is in terms of capability to operate effectively and creatively in the made world. The goal is increased ‘competence in the indeterminate zones of practice’.*

(Interim Report, D & T Working Group, 1988: 3)

This unique purpose of D & T remains a distinctive feature after a decade (Barlex & Pitt, 2000).

Recently, in the Foreword to *Design and Technology in a Knowledge Economy*, Malcolm Shirley, Director General of the Engineering Council, described D & T as ‘a learning experience which is unbounded by fixed bodies of traditional knowledge, and transcends the academic/practical divide’ (quoted in Kimbell & Perry, 2001). He stressed the potential of D & T for activities that support
innovation and emphasised D & T’s centrality in the school curriculum as it becomes a model for the combination of skills needed in a knowledge economy, and an exemplar for other subjects in delivering effective teaching and learning. He hinted at the uniqueness of D & T saying it is ‘more than just a subject … More than any other area of the curriculum, it is about capability for all’.

Part of the original foresight was that D & T education would be less about ‘knowing that’ than about ‘knowing how’; less ‘propositional knowledge’ but rather ‘action knowledge’; not so much ‘man the understander’ (homo sapiens) but rather ‘man the maker’ (homo faber) (DFE/WO, 1988).

Davis (2000) suggests that what first distinguished D & T from other subjects was its framework of assessment (Attainment Targets) which were ‘process’ rather than ‘content based’. Although the development of this ‘proactive process-centred view’ of D & T has been seen in other areas of the curriculum (eg process science and process maths), uniquely in D & T the process defines the discipline (Kimbell et al, 1996: 28). D & T is about creating change in the made world, about understanding these processes and developing a capacity for bringing about changes, ‘uniquely, D & T empowers us to change the made world’ (Kimbell & Perry, 2001).

The model devised by the Working Group was significantly different from what had previously been taught in schools, incorporating aspects from CDT, home economics, business studies, and art and information technology into a design-focused, student-centred subject (Paechter, 1993). The Working Group distinguished D & T from other subjects such as science, stressing that the special qualities about D & T are that it is:

...always purposeful, ie developed in response to perceived needs or opportunities, as opposed to being undertaken for its own sake), takes place within a context of specific constraints (eg deadlines, cash limits, ergonomic and environmental requirements as opposed to unconstrained, blue-sky research) and depends upon value judgements at almost every stage.

(Interim Report, D & T Working Group, 1988: 4)

Similarly, what makes the educational experience of D & T different from science is the type of cognitive processes involved. The Working Group (1988) emphasised that D & T is more about ‘what might be’ than ‘what is’, ie ‘the conception and realisation of the form of things unknown’. They characterised this as a ‘visionary activity’. Drawings, diagrams, plans, models, prototypes and computer representations are all employed in developing the imagined artefact, system or environment. It is this special type of creative thinking that is associated with designers and technologists and is ‘different from and complementary to verbal modes’ of thinking (DFE/WO, 1988). In sum, the particular creative aspects unique to design activity in a technological context are that the person has to imagine ‘a concrete object which does not yet exist, and has to determine spatial and temporal details which cannot yet be observed, but will have to be created by the designing and manufacturing process’ (Ropohl, 1997).
Comparisons of the relationship between ‘Art & Design’ and ‘D & T’ in relation to ‘creativity’ have shown that although there is obviously some overlap between these two subjects, D & T is more instrumental than Art & Design and is thought to have a greater external focus (Rutland & Barlex, 2002). However, some overlaps would seem to contrast with the unique features suggested by other authors.

Kimbell et al, (1996) argue that the unique concrete language employed in D & T, such as graphics and models, strengthen its importance educationally as it facilitates pupils’ cognitive development. Through this language ‘pupils are empowered to identify failings in the “made world” and to do something to improve things’. They suggest that such a capability encourages independence and resourcefulness; it also combines practical, intellectual and emotional challenge in a way that is quite unique within the curriculum (Kimbell et al, 1996: 28; Kimbell, 1997: 46).

Some clues are found in the National Curriculum statements which describe each subject’s distinctive contribution. The statement for D & T states that:

> the subject calls for pupils to become autonomous and creative problem solvers, as individuals and members of a team. They must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems.

(DfEE/QCA, 1999)

However, others believe that insufficient attention was given to the potential for overlap between subjects, and thinking in the late 1990s was that the National Curriculum should be efficient, with little duplication between subjects (Barlex & Pitt, 2000; Barlex 2002).

Kimbell and Perry (2001) have gone on to argue that D & T has a distinctive pedagogy: its model of teaching and learning not only draws upon different learning styles than other National Curriculum subjects, but also employs a richer range of learning styles. D & T aims to develop capability in which the pupil is an active participant. The distinctive model of teaching and learning:

- is project based
- takes a task from inception to completion within the constraints of time, cost and resources.

Students have to learn how to:

- deconstruct the complexity of tasks and the values inherent in the concept of improvement
- be creative, conceiving ideas and planning what does not yet exist
- model their concepts of the future
- make informed judgements
- manage both complexity and uncertainty in their projects
- deal with multi-dimensional and value-laden tasks.
Kimbell and Perry (2001) note that the task-centred nature of D & T requires a different approach from other curriculum subjects. They believe that the educational elements require pupils to acquire and create new, task-related knowledge while demonstrating their ‘active, purposeful deployment of understandings and skills’. As has already been mentioned, the difficulty for D & T is to assess their performance in a subject where knowledge is a process.

This inter-relationship between conceptual knowledge and procedural knowledge was highlighted by others (McCormick, Murphy & Hennessy et al, 1994; SEAC, 1991). Levinson et al, (1997) chart the changes from the early 1990s when there was a greater emphasis on (conceptual) knowledge in D & T. They suggest that this was partly influenced by the Engineering Council Report that proposed ‘an appropriate mix between solving problems and knowledge/skills’ and that ‘an electronics solution cannot be applied unless electronics has been learned’ (Smithers & Robinson, 1992). Prior to the Revised Order of 1995 the preferred method within D & T was to pass on appropriate knowledge as and when needed (McCormick & Murphy, 1994). The emphasis now is on knowledge likely to be useful to developing particular solutions (through focused practical tasks and investigation disassembly and evaluation activities) before pupils tackle a designing and making assignment (Barlex, 2003). Although others (eg Kimble & Perry, 2001) point out that the issue now has shifted from ‘passing on knowledge’ to pupils ‘learning how to learn’.

Many point to the importance of co-operative learning. Some (Henley & Lyle, 1995; Hennessy & Murphy; 1999) identify D & T as a rich environment for co-operative learning in which a range of designing skills can be developed (Koutsides, 2001). And Hennessy and Murphy (1999) argue that D & T is a unique subject for involving procedural problem solving activity where co-operative learning between peers relates to physical manipulation and feedback, and in which concrete models and graphical representations play an important mediating role.
4: Pupils’ Experiences of Design and Technology

4.1 Summary

One main question was explored in this section.

- What are pupils’ curricular experiences of D & T?

_The main findings on pupils’ curricular experiences are summarised below._

**Activities:** A wide variety of stimulating tasks was described in the literature. However, some suggest that recent emphasis on literacy and numeracy in primary schools is impinging on time spent on D & T, so that often activities lack depth or breadth. ICT use is fairly extensive at both primary and secondary levels. Internet resources are proving useful for stimulating project ideas.

**Characteristics of pupils:**

_Age:_ Since its inception, D & T has been a compulsory subject for all children from age 5 to 16. With effect from September 2002 D & T pupils will have a statutory entitlement of access to D & T but it will not be compulsory from age 14 upwards.

_Ethnicity:_ There was very little information relating specifically to ethnicity in relation to D & T in the literature.

_Disability:_ Literature relating to disability/special educational needs in relation to D & T within mainstream schooling was scant.

_Gender:_ There is a lack of current reliable and unequivocal evidence concerning gender issues in D & T.

**Types of provision experienced:** Evidence is scant but Ofsted reports that:

- primary school D & T resources, accommodation and facilities need improvement
- over 20% of secondary schools are failing to comply with the requirements of the National Curriculum for D & T
- recruitment of suitable D & T teachers is becoming problematic.

**Teaching methods:** The literature indicates a fairly limited amount of research on methods used by teachers. Nevertheless, papers in D & T journals highlight the potential of D & T to develop cognitive skills through a variety of different teaching methods including project-based group work.

**Pupil results:** Although statistics for the current year are provisional due to marking anomalies, the success of D & T is demonstrated in the upward trend of pupil performance in GCSE, GCSE short courses and A-level examinations.

**Links to professional design activity/local business:** There is some evidence that teachers are drawing on support from external professional and business sources to help them deliver up-to-date design facilities in D & T.
4.2 What are pupils’ current curricular experiences of D & T?

One of the aims of this review is to attempt to answer questions about pupils’ current curricular experiences of D & T. Therefore, this section draws mainly on recent literature and reports published after 1995 which show the current state of affairs. Older valid studies are included where recent research is absent. In addition, it has not been possible within the time limit of this review to identify statistics that relate to D & T in isolation.

4.2.1 Types of activities:

The Programmes of Study (PoS) ‘knowledge, skills and understanding’ for all Key Stages of D & T currently include:

- developing, planning and communicating ideas
- working with tools, equipment, materials and components to make quality products
- evaluating processes and products
- knowledge and understanding of materials and components.

At Key Stages 3 and 4 there is an additional PoS:

- knowledge and understanding of systems and control.

Kimble et al, (1996) point out that one of the main characteristics of technology tasks is that they produce an outcome that results in some change in the ‘made world’. These tasks provide opportunities for teaching and learning but teachers must be aware of:

- the balance between the product purpose and the teaching purpose
- the relationship between particularised tasks and generalised contexts
- the balance between teacher control and pupil autonomy.

With the foregoing features in mind, a selection of activities, as detailed in The Journal of the Design and Technology and also from the National Curriculum website <http://www.ncaction.org.uk>, is presented below.

**Primary**

- **Push and pull model:** 1st year class made models with adult support and evaluated the final product (McInnes, 2000).
- **Making a moving picture using sliding and lever mechanisms:** 1st year pupils practised making simple models, and designed and decorated one of their own to fit a story (Ward, 2001).
- **Make a coal cart:** Upper juniors worked in small teams to make a model coal cart from history work (Newcomb, 2000).
- **Design and make a model boat:** Year 2 work linked to transport theme and all areas of curriculum (Anderton, 2000).
- **Eat more fruit and vegetables:** Project with Year 2 to design and make a fruit salad. Project linked to literacy work and health (Peters, 2002).
Design on the Curriculum?

- **A sandwich snack for Mr Grinling: A design and technology project**: Year 2 and 3 used whole class teaching, small group and individual work to investigate various food products (Higgins, 2002).

- **Money containers**: Year 5 designed and made a belt bag or purse using simple textiles techniques (Jones, 2001).

**Secondary**

Examples of specific projects for secondary schools were not so common or explicit as those outlined for the primary sector, but tended to function as an information source about initiatives and subject or equipment developments. They include the following.

- **Millennium products**: An educational resource of products identified as being innovative by the Design Council (in conjunction with The Nuffield D & T Project and the Design Museum).

- **A home for life**: This case study followed a cohort of Year 10 students on a 5-day collaborative project using skills from D & T, Mathematics and Science. Students were given the challenge of ‘What makes a Home for Life?’ (Messenger, 2000).

Other examples of secondary level work were derived from those on the National Curriculum website <http://www.ncaction.org.uk>.

- **Talking puppet head – systems and control**: for KS3, level 3
- **Information board – systems and control**: for KS3, level 4
- **Toothbrushing timer – systems and control**: for KS3, level 6
- **Novelty cake for a supermarket – food technology**: for KS3, level 6
- **Drawer detective – systems and control**: for KS3, level 5
- **Halloween snack – food technology**: for KS3, level 3
- **Sweet and savoury pastry – food technology**: for KS3, level 5
- **Ensuring quality production – food technology**: for KS3, level 7.

Over the past decade, more sources of information and ideas have become available to teachers for classroom activities; some via journals dedicated to the subject and others from government, industry initiatives etc. Increasingly, this is making access to such resources easier. DATA’s website <http://www.data.org.uk> describes the following initiatives.

**FOOD TECHNOLOGY:**

- **Sainsbury’s Taste of Success Food Awards Scheme** is focused around successful completion of a practical food task by pupils aged 5 to 11. <http://www.jsainsbury.co.uk/tasteofsuccess>
**The Food Technology Website** is an interactive website that details many aspects of food manufacture and has direct links with food industry professionals and other websites. [http://www.foodtech.org.uk]

**School Nutrition Action Groups (SNAG)** are school based alliances to work together to review and expand the range of knowledge about food and drink, and to promote healthier diets. [http://www.healthedtrust.com]

**SPECIFIC INITIATIVES:**

- **The CAD/CAM in Schools Initiative** delivers CAD software, Pro/DESKTOP, ArtCAM and SpeedStep software to schools and colleges. [http://www.cadinschools.org]
- **Marconi ETC** is a collaborative project that promotes, develops and supports electronics and communications technology in secondary schools. [http://www.marconielect.org]
- **Young Foresight Initiative** has piloted approaches to developing designing skills (see Barlex, 2001b).
- **The Nuffield Design and Technology Project** (eg see Givens & Barlex, 2001; Barlex, 1998) aims to establish a clear pedagogy that teachers could use to teach effectively and develop curriculum materials that utilised this.
- **The Nuffield Primary Design and Technology Project** has developed resources for Primary Teaching of D & T (see Barlex & Mitra, 1999; Barlex, 2001a) which are available via their website. [http://www.primarydandt.org.uk]
- **The Nuffield Design and Technology Project and the Design Museum** collaborated in developing educational resources for secondary schools that make use of ‘Millennium Products’ that were identified as being innovative by the Design Council (Barlex, 2000a).
- **FEATHERS**: This was funded by The Boots Company (see Webster, 2000) and uses various themes for its workshops, eg making Christmas tree lights using simple circuits.

**THE OFSTED PERSPECTIVE:**

We have taken Ofsted reports on inspections of schools as indicators of countrywide experience of D & T activities. A recent report (Ofsted, 2002a) on D & T in Primary schools states that: ‘the lack of time for D & T restricts the depth and breadth of activities’.

In addition,

The majority of designing and making tasks have tended to require pupils to use only paper, card or wood, with little work with food or, especially, textiles. Again this year, there is a slight increase in work with systems and control – with pupils mainly using simple mechanisms. An increasing proportion of schools is using Information and Communication...
Technology (ICT) as an integral part of their making procedures, usually with a printer, and a much higher proportion use ICT to record results of their evaluations. Within this overall picture, some schools are employing ICT more regularly in D & T contexts.

Another Ofsted report (2002b) highlights positive aspects of ICT use in D & T in secondary schools:

- an increasing proportion of pupils use ICT to develop and communicate their design ideas. This may be, for example, in the simulation of electronic circuits or food recipes, or for the analysis of surveys and the production of graphs and drawings to improve the presentation of pupils’ research and their design proposals.

(Ofsted, 2002b)

Inspectors also cite an example of positive electronics work observed in secondary schools.

- Pupils in a Year 8 class use an electronics simulation program to explore the effects of changing values of components in a circuit and are then able to develop simple circuits to achieve a specified function. The pupils learn quickly and, having built the circuit, are able to use the same software to check electrical values to locate faults.

4.2.2 Characteristics of pupils – eg age, disability, ethnicity and gender

Below we present evidence relating to the affects of age, disability and gender on the learning and teaching of D & T.

Age: Since its inception, D & T has been a compulsory subject for all children from age 5 to 16. The DfES consultation paper 14-19: Extending opportunities, raising standards proposes a new structure for the National Curriculum at Key Stage 4. Pupils will have a statutory entitlement of access to D & T but it would not be compulsory from age 14 upwards. However, as Kimbell (1994) points out:

> anything that pupils are expected to be able to do at the age of 16 they need to be getting started from the very beginning. Whilst the teacher’s presentation mode and the child’s response to the material can be expected to change (Bruner, 1964, 1968, in Kimbell, 1994) and the sophistication of it must be expected to increase, the basic constituents of capability must be evident in courses for every age.

Ethnicity: Research articles yielded very little information related specifically to ethnicity within D & T in the UK. It can be surmised that the main area where ethnicity may prove problematic may be in relation to food technology. Siraj-Blatchford (1995) goes so far as to suggest that D & T risks supporting racist ideologies by assuming that technology must be advanced and sophisticated as opposed to appropriate to circumstances. This has to be challenged and unlearned, by both teachers and pupils.
**English as Additional Language:** An example of activities to help pupils with English as an additional language (EAL) was identified. A London multicultural secondary school with a large transient population of pupils developed a learning resource to introduce pupils with English as an additional language to D & T (MacPhee, 2000). Typically, these children have little written or spoken English, may join in the middle of a project, and may find the D & T classroom intimidating. In these circumstances, there are three key issues:

- the task must be fairly simple, given their limited access to the language
- the resource must be easy to store and access
- the project must be suitable for use in any material specialist room.

The only real limitation of the above activity that was cited was the potential effects of being treated differently from the rest of the class. In addition, it serves principally as an introduction and does not deal with follow up or integration into the full D & T syllabus.

**Disability:** Only special educational needs in mainstream schooling was to be considered for this review. The majority of the information accessed related to special schools and, therefore, has been excluded. Cunningham (2001) did, however, explore aspects of D & T and autism. His findings based on a small case study of two children with autism (at KS2) revealed that D & T is an essential element for such children as they benefit from a curriculum that incorporates a problem-solving approach in which independent learning is encouraged.

**Gender:** There is a lack of current reliable and unequivocal evidence concerning gender issues in D & T. (Catton (1985) and EOC (1987) are both outwith our period and also refer to Craft, Design and Technology rather than D & T.) It would appear that interest in the subject in relation to D & T dwindled around five years ago. The much-needed research called for by the APU back in 1991 does not seem to have materialised. There is evidence that D & T precursor subjects were strongly sex-differentiated and gender-stereotyped (Paechter, 1993; Harding, 1997), with the exception of TVEI (Layton, 1995). The introduction of D & T into the curriculum for all pupils was seen as a means of extending equal opportunities to both sexes and of creating gender neutrality (eg Layton, 1995; Harding, 1997).

The Assessment of Performance Unit (APU) had been set up within the DES in 1975 to establish standards of performance in the major curriculum subjects. The APU work on D & T operated between 1985 and 1991 and found that sex disadvantage in technology education can work both ways depending on the activity (see also Harding, 1997). The APU assessed performance of 15-year-old pupils on different test structures, different contexts and on specific tasks (SEAC, 1991). As shown below, gender differences emerged, although these were often subtle, eg there was an interaction effect between test structure and context.
• Tests requiring reflection favoured girls, whereas active tasks favoured boys.
• The performance of low-ability girls was found to be particularly fragile.
• Context was important, with girls excelling in people contexts and boys in industry contexts, with environment contexts being gender neutral.
• Context effects were exaggerated for low-ability pupils.
• Girls outperform boys in all areas of communication.

The APU analysis of pupils’ conceptual understanding of ‘materials’, ‘energy systems’, ‘aesthetics’ and ‘people’ revealed that only ‘materials’ had no significant gender effect. However, during 1999–2000 a small scale research project on the impact of a curriculum initiative on literacy (Stables & Rogers, 2001) found that boys thinking and reflective skills can be enhanced by literacy interventions in D & T. Other studies (cited in Harding, 1997) suggest similar findings to those of the APU concerning low ability girls (eg Galton, 1981 in Harding, 1997).

Further older studies (eg Primary Technology Project set up in 1987) showed that in spite of remedial efforts in construction experience of primary schoolgirls, girls had not caught up (Brown, 1993). Similarly, disparity between girls and boys performance in science and technology widens between the ages of 11 and 15 years (Murphy, 1986). APU (1991) findings suggested that sex-stereotyped toys may contribute to the differential experiences of children from an early age and provide grounding for later learning (SEAC, 1991; Johnson and Murphy, 1986). (It should be noted, that this partly conflicts with conclusions from an Australian, small scale research project (Rogers, 1998) that suggested ‘design, making and appraising’ activities are ideal for introducing and developing non-sexist pedagogical initiatives and provide real equality of opportunity for all children. If gender neutral activities are introduced early in primary school, they may avoid remedial measures for developing girls’ technological capability at a later stage. However, it should be noted that these conclusions were based on 25 children only, with no control groups and developmental stages were not taken into account.)

There is some evidence that gender stereotyping in D & T is decreasing (see for example a pupils’ perceptions study by Hendley & Lyle, 1996). Wright (2003) suggests that D & T resources demonstrate greater inclusivity in their use of images and topics than many other subjects do. Others warn of a growing problem of more general underachievement of boys (eg see Spendlove, 2001a). However, aspects of the framework for D & T have been criticised for limiting the chances of gender neutrality (Paechter, 1993; Harding, 1997). The 1995 National Orders ‘design and make’, focused on ‘construction’, and ‘evaluating products and their applications’ focused on ‘technical performance’ rather than on the aesthetic, social or environmental aspects which have been shown to favour girls’ reflective skills (Harding, 1997). Harding (1997) anticipated that
the Food option at KS3 would prolong sex differentiation in a subject which was already vulnerable to sex-stereotyping.

Similarly, statutory pupil assessment and unreliable assessment practices may have contributed to the gender gap, resulting in demotivated pupils (Wilmut, Wood & Murphy, 1996 in Spendlove, 2001b). Teachers were also found to have a gender bias in displaying differential expectations of girls and boys in Science and Technology (GIST), even when both had similar pupil profiles (Whyte, 1986; Harding, 1997).

It is interesting that ten years after the APU report, Spendlove (2001b) concluded that:

the APU remains the only thorough analysis of design and technology by assessment and gender and clearly illustrates a way forward through further research in this area to offset the current gender imbalance.

4.2.3 Types of provision experienced

Primary

The most recent Ofsted reports (2002a) maintain that:

• a quarter of schools have good resources and accommodation for D & T
• one school in ten has poor facilities
• many schools have insufficient space for pupils to work or for tools & materials storage
• one-third of schools rely excessively on recycled materials, which constrains the range and quality of work. Often this reflects very low levels of capitation for D & T.

Secondary

Inspectors (Ofsted, 2002b) report:

• there has been a slight increase in the proportion of schools, now more than one in five, failing to comply with the requirements of the National Curriculum for D & T
• despite improvements, particularly in specialist Technology Colleges, resources and accommodation for D & T are poor in one fifth of schools
• the average size of groups has stabilised this year but is still too high. This imposes additional health & safety risks, particularly in KS 4, and tends to depress achievement
• although the use of ICT is still very patchy, an increasing proportion of pupils uses ICT to develop and communicate their design ideas.

Ofsted also reiterated comments from their previous year (Ofsted, 2001a) namely:
Design on the Curriculum?

- of those schools not complying with the National Curriculum requirements, three quarters fail to ensure that all pupils follow the PoS in Key Stage 4, and a third fail to cover significant parts of Key Stage 3 requirements
- planning of Key Stage 3 continues to be weak and is often related to how many schools organise their curriculum
- proportionately fewer pupils are taking the GCSE short course as teachers find it difficult to cover the syllabus in the time available.

4.2.4 Types of teaching methods used

The Revised Order for D & T (SCAA, 1995) suggested that the following types of activity should be used as a basis for teaching design: focused practical tasks (FPTs), investigation disassembly and evaluation activities (IDEAS) and designing and making assignments (DMAs). This had been previously developed and piloted in schools through the Nuffield Design and Technology Project (Barlex, 1998b; Givens & Barlex, 2001).

Although little relevant research on teaching methods directly related to D & T was identified, the activity section (4.2.1) above, and case studies outlined in recent years of the DATA journal indicate that D & T provides opportunities for teachers to use a range of methods. Most of these indicate that teachers interact with individual pupils, small groups and whole classes, in different contexts and facilitate opportunities for pupils to learn in a wide variety of ways, including teacher-supported learning and pupils’ reflection on their own work. Indeed, Hennessy and Murphy (1999) argue that the role of the teacher in D & T is central, particularly task structuring, agendas and pedagogic strategies for supporting learning through collaboration.

Two organisational approaches to teaching (‘spaced’ and ‘massed’) were compared in a small case study related to control work with a Year 6 class (Pritchard, 2001). The massed method involves a reasonably long period of time, eg a one-off whole day experience relying upon support from outside school, contrasted with a spaced approach, eg a series of shorter sessions spread over half or whole term. Pritchard concluded that both approaches have merit, although the least effective in the long term is probably the one-off approach. This study exemplifies teacher resourcefulness in using out of school expertise by liaising with a well-equipped local Business Education Partnership Centre.

Examples of the use of structured learning were provided in The Design Museum initiative which lends schools a ‘Mystery Loan Box’ containing a collection of items. Stables (2001) found that handling collections for product analysis activities promotes enthusiastic response among teachers and learners in primary, secondary and special school environments and the development of a broader range of skills such as problem solving, observation and collaboration (Stables, 2001). Stables also identified that collaborative work, group discussion, group decision making, whole class and group discussion and discovery-based approaches developed children’s literacy
skills and also ‘helped with the challenge of getting children to really look at something’.

Peer collaboration is considered a valuable learning mechanism not sufficiently exploited by teachers to assist pupil learning (Hennessy & Murphy, 1999). Although collaborative learning often features in D & T literature, it is important to distinguish between ‘learning to collaborate’ and ‘learning through collaboration’ (Hennessy & Murphy, 1999). ‘Fostering learning through collaboration requires continuous teacher support’ (Huber & Eppler, 1990 in Hennessy & Murphy, 1999). Similarly, ‘group work’ and ‘teamwork’ are not necessarily the same as collaboration; neither are the terms ‘co-operation’ and ‘collaboration’ interchangeable. Such nuances in meaning are explored further in Hennessy and Murphy’s discursive paper looking at the potential of D & T as an environment for collaborative problem solving.

Despite these positive examples, recent Ofsted reports (2001a) illustrate that some aspects of teaching are still weak, particularly in some secondary schools.

- The use of day-to-day assessment is still weak, especially in Key Stage 3.
- Planning to achieve effective differentiation is often weak, with teachers setting the same work for all their pupils and expecting them to work to the best of their ability, often without making their expectations clear.
- There is increasing evidence that teachers provide coaching which allows pupils to pass through the assessment ‘hoops’ for D & T GCSE coursework at the expense of following the rationale of wider D & T learning objectives.

4.2.5 Pupil results

At the time of writing statistics for the current year are provisional due to marking anomalies. However most demonstrate pupils’ continuing success in D & T as an examinable subject. Available evidence from the DfES, Joint Council for General Qualifications (JCGQ), the Qualifications and Curriculum Authority (QCA) official statistics web pages and Ofsted Reports is summarised below. 92.8% of students entered for D & T took the full GCSE course, 5.2% took the short course and only 2% the Entry Level Certificate.

General trends

GCSE

- Summer 2002 provisional results for GCSE (JCGQ at <http://www.jcgq.org.uk>) indicate a consistently strong performance by students across all subjects.
- There was a very small rise (0.3%) overall at the highest grades A* and A. Pupils gaining grade C and above increased by 0.8% from 57.1% to 57.9%.
- In almost all GCSE subjects girls continue to outperform boys, as in previous years, with a widening gap in Information Technology.
Results for D & T

**GCSE**

- In 2002, 7.7% of total entries were for D & T. Only English, English Literature, Mathematics and Science had greater numbers entering.
- 2002 showed a very slight fall in the percentage of both male and female student entries (0.1%) for D & T compared to 2001.
- This year (2002) there were proportionately more male (8.1%) than female (7.2%) entries.
- There was a 1% rise in the proportion of D & T students gaining grades A*–C (52.1%–53.1%) which was slightly above the 0.8% rise for all subjects.

It is interesting to note that figures from awarding bodies in August 2002 as compiled by HMI indicate that the distribution of different focus areas was as follows:

- resistant materials 28.0%
- graphic products 25.8%
- food technology 24.9%
- textile technology 10.4%
- electronic products 4.7%
- systems and control 3.6%
- design engineering 0.5%
- general design 1.2%
- automotive studies 0.2%

**Post-16 D & T examination results**

Examination results show an overall improvement (DATA website <http://www.data.org.uk>).

**Technology subjects summary**

- A2 entry indicates a 1.9% increase on 2001.
- AS entry indicates a 22% increase on 2001.
- A2 results based on grades A–E indicate a 3.9% improvement, and on A–B a 12% improvement in overall performance.
- AS results based on grades A–E indicate a 5.2% improvement, and on grades A–B 29% improvement in overall performance.

**D & T trends 1992-2001**

The QCA Inter Examination Board Statistics – Final Results for the years 1992–2001 show:
• a large rise in numbers of candidates taking D & T A-level and GCSE full and short courses. (Exceptions being a slight decrease in numbers of candidates for D & T GCSE short courses for the past two years.)

• a steady increase in the percentage of pupils achieving grades A*–C in A-level and GCSE full and short course D & T throughout the decade

• unclassified gradings have declined for D & T A-level and GCSE short courses.

Pupil results in primary schools

Recent Ofsted reports (eg 2002a) explain that:

primary schools assessment of pupils’ learning is generally based on teacher’s judgement of pupils’ capabilities, as evidenced by their observation of D & T activity and the results of the designing and making. While this approach is not precise, it is often effective. It forms the basis for teachers to modify their planning and inform pupils of their attainment.

• such assessment is satisfactory or better in four-fifths of schools

• by contrast more formal assessment of pupils’ D & T capability is less effective, remaining poor in a third of schools (Ofsted, 2002a)

• pupils’ achievement in designing is weaker than in making (2001a and 2002a).

Pupil results in secondary schools

Ofsted reports for the past two years (2001a and 2002b) are indicated below.

• Results in design and technology (D & T) continue to improve. Girls again out-performed boys in all aspects of D & T, with 59% of girls gaining grades A*–C compared with only 42% of boys.

• Post-16 work continues frequently to be outstanding, with 30.4% of students gaining grade A or B at A-level.

• Achievement is improving in each key stage, being at least good in two-fifths of schools in Key Stage 3, nearly half in Key Stage 4 and in three-fifths in post-16 work.

• Pupils with special educational needs (SEN) make comparatively better progress than in most other subjects, but higher attaining pupils often under-achieve.

• During Key Stage 3 pupils become better at planning their work and researching the context, learn more about materials and processes, and increasingly are able to make good-quality products. Progress in ‘making’ continues to be better than ‘designing’ which Ofsted laments is an ‘intractable problem reported over many years’.

• In Key Stage 4, higher achieving pupils are those who have learned to organise their time and resources carefully. Weaker pupils do not organise
their time well and need teacher intervention to provide direction and short-term deadlines, and to help prioritise.

- Students’ designing and making skills and their general understanding of D & T continue to be better than their specialised technical knowledge (Ofsted, 2002b).

- Students’ attainment on A-level courses improved again this year, and the number of students following these courses continues to rise at a rate well above the average of all subjects. Again, girls outperformed boys, by nearly 7% for the higher grades. The introduction of new AS courses caused many problems, particularly because teachers found specifications unclear and had insufficient text-books and other sources of information (Ofsted, 2002b).

### 4.2.6 Links to professional design/ vocational training/ business/ out-of-school activities

#### Links to professional design activity/local business

The 2000 Orders for D & T made CAD/CAM compulsory at Key Stage 3. This has been well received in schools (eg see Breckon, 2000; 2001), and recent Ofsted reports (2002b) confirm that most of the students they observed were confident and creative users of complex equipment; in particular CAD/CAM and the skilled use of industrial standard software.

Much of the outstanding work of students’ main designing and making project is linked to industry or a community-based project and nearly always involves a real client. Students frequently make presentations of their proposals, or of completed projects, to clients and larger audiences, usually using ICT and often incorporating complex multimedia elements. (Ofsted, 2002b)

In addition, all pupils at Key Stage 4 must show an awareness of industrial practice. Ofsted (2002b) report that although teaching of this aspect varies widely, there is inspection evidence to show that more teachers use experts from outside school to act as consultants or to support the work in other ways, such as providing independent testing and evaluation of the products pupils have made. Some primary schools also use local Business Education Partnership Centres to enrich pupils’ access to resources not available in schools (eg see Pritchard, 2001).

Specific examples from the literature include the London Borough of Bromley, where the Education Business Partnership (EBP) has encouraged and supported schools and local businesses to work together to enhance the curriculum (Richard Green in Gardner, 1996). Primary class projects were linked to a variety of local businesses (see Gardner, 1996) including a local leisure centre, McDonalds burger bar, Crystal Palace Football Club, a Waitrose supermarket, Body Shop, the local Environmental Education Service, local travel agents, and a local school for the disabled.

The Machine Tool Technologies Association (MTTA) Technology Challenge proved a valuable asset in exciting primary aged children about opportunities in
engineering (see Jupe & Link, 1999). With the support of Education and Business Partnerships 37 schools were linked with machine tool suppliers and user companies to work together on manufacturing based projects throughout the year.

**Out of school activities**

Ofsted (2001) report that work in extra-curricular activities ‘is often of a very high order and is used by an increasing proportion of schools to provide support and challenge for gifted and talented pupils. Sometimes the quality of work in these clubs is better than that produced in the mainstream curriculum’. Examples include the ‘FEATHERS’ (Family Evening Activities That Help Everyone Relax Socially) study support initiative in primary schools (e.g. Webster, 2000). In the Nottinghamshire area, the Boots Family Learning Project builds around a series of after-school workshops which involve D & T activities. The aim is to enhance links between home, school and the community. Other examples include Young Engineers Clubs and design and technology work undertaken as part of schools’ performing arts performances.

Moynihan _et al_., (2001) studied an extra-curricular after school food club (The Good Food Club) in which children, predominantly from low-income backgrounds, were taught how to prepare healthy foods. The study found that success was linked to having a more hands-on approach rather than a formal school-type lesson, and the provision of all ingredients and containers for taking food home.

### 4.2.7 Progression post-14 and post-16

**General**

The Government’s recent reforms have proposed a more flexible curriculum for 14- to 19-year-olds (*Extending opportunities, raising standards*, Feb 2002, Cm 5342). New vocational subjects have been introduced with effect from September 2002. These reforms aim to provide a more flexible curriculum for students which is more tailored to their aptitudes and aspirations. In addition the reforms will provide more opportunities for students to follow a vocational route and extend opportunities for work-based learning.

From September 2002, the Part One, Foundation and Intermediate GNVQs were replaced with vocational GCSEs. Eight new GCSEs in vocational subjects are included.

- Applied Art and Design
- Applied Business
- Engineering
- Health and Social Care
- Applied Information and Communication Technology (ICT)
- Leisure and Tourism
- Manufacturing
- Applied Science.
Theoretically, more vocational training is available for students than before. In particular, it seems that most of these new GCSE subjects have commonalities with D & T but this will need to be monitored.

**D & T progression post-14 and post-16**

Ofsted (2002b) was positive concerning pupil proficiency in using the Internet for research and investigation. Inspectors declared that: ‘at Key Stage 4 most pupils use a wider range of research skills and understand the importance of finding out about user needs and preferences and using this information to inform their designing’. At Key Stage 4 there is also greater use of ICT, CAD/CAM equipment and techniques to improve the quality of design, development and accuracy of manufacture.

The most noticeable change in Key Stage 4 and post-16 D & T has been the rapid development in the use of ‘state-of-the-art’ 3D CAD software in schools. Starting from nothing in September 1999, by the end of this academic year two-thirds of schools has at least one teacher trained in the use of a software package, made available free of charge by software companies.

(Ofsted, 2002b)

Similarly, Ofsted (2002b) reported that nearly all Key Stage 4 pupils working in food technology or electronics confidently use ICT simulation software to model their design ideas. However, on a negative note, the report found that ‘many pupils are less effective in developing an adequate detailed design specification that will provide them with the information they need for further development and evaluation. This inevitably limits the success of their designs and the effectiveness of the resulting products’.

Also:

the disapplication of the National Curriculum for D & T in Year 10 has trebled in the last year, compared with Year 11, doubling for boys to 8,700, but quadrupling for girls to 10,000. Although there has been an increase of one-fifth in the numbers disapplied to allow more time to be given to work-related learning, most of the increase is accounted for by schools which allow some of the most able pupils to concentrate on other curriculum area, mainly the arts, humanities or languages. This has led to a reduction in the number of more able pupils having a technological learning experience in Key Stage 4.

(Ofsted, 2002b)

Planned progression from National Curriculum, through GCSE and 16+ pathways and on to higher education, have been criticised by some researchers (eg Norman, 1997) who claim that the plethora of courses and course options may create an insufficiently standardised basis for later progression.
5: The Effects of Including Design and Technology in the National Curriculum

5.1 Summary

One main question was explored in this section.

- What has been the impact of D & T on pupils’ skills, understanding, standards, attendance, take-up, social inclusion and cross-curricular learning?

The key findings are summarised below.

**Key Skills development:** Although most accept that D & T has the potential to develop key skills, there is scant evidence of actual improvement relating directly to D & T.

**Cognitive development:** The consensus is that D & T does provide opportunities for pupils to develop high order thinking skills and problem solving skills, but opinion is divided on which activities contribute most, and which children gain most benefit.

**Raising standards of achievement:** It has not been possible to determine what effects have been due directly to D & T. However, again, the subject has the potential to impact on achievement in literacy and numeracy.

**Enhancing attendance patterns:** There was a paucity of information on truancy and attendance related to D & T.

**Tackling issues of social exclusion:** There were few research studies related specifically to D & T and social inclusion.

**Cross-curricular learning:** There is evidence to confirm that cross-curricular learning is fundamental to D & T activity in primary schools. However, the effects of such learning are less clear.

5.2 Impact of Design and Technology

This section identifies the impact of introducing D & T into the National Curriculum. In many cases it has not been possible to determine effects of D & T as a subject, either because research has not been undertaken or relevant data (eg statistics) have not been obtainable within the timescale of this review. Despite relatively glowing reports from Ofsted inspectors on D & T teaching, there was less satisfaction with teaching at KS3 level during the early years following its inception (DES, 1992: 18-19). Partly this was due to the fact that at secondary level the new D & T subject grew out of an amalgam of five separate disciplines:

- art and design
- business studies
- craft, design and technology
- home economics
- information technology.
Kimbell (1996) describes three ways in which schools began to implement this change: one, a 'status quo – single-subject approach' where delivery continued much as before, with each individual discipline making its contribution; two, 'a federated approach' which necessitated active planning, liaison and discussion between departments; and three, 'an integrated approach' which accepted D & T as a new construct where the emphasis was more on a whole new technology team. However, over the past decade, revisions of D & T curriculum have resulted in more understanding of what can be achieved (Kimbell, 1999) and contribute to other areas (Davies, 2000).

### 5.2.1 Key Skills development

Some suggest that key skills occur naturally within group-based working within D & T (eg Summer, 1998, in Barlex, 1998; and Davies, L, 2000). D & T has added to the development of Key Skills (Davies, L, 2000). Key Skills provide a foundation for common areas of learning through the six areas of competence. Louise Davies (2000) has outlined how D & T specifically contributes to these. With specific reference to Key Stage 3, she argues that: D & T aids communication, and improves numeracy, information technology, working with others, improving performance, problem solving and creativity. Furthermore, Davies stresses that if pupils are aware of the key skills they are learning in D & T ‘they will understand the wider contribution this subject is making to their education’.

### 5.2.2 Cognitive development

There is clear evidence that the different teaching methods and the range of pupil activities within D & T assignments provide opportunities for cognitive development. From a study, which included classroom observation, Twyford and Jarvinen (2000) concluded that much of pupils’ knowledge of D & T was learnt through social interactions: ‘pupils’ capabilities were enhanced through their direct active socio-cultural interactions within a range of classroom settings involving different teaching methods’. However, McCormick and Davidson (1996) have indicated that concentration on product outcomes may undermine the design process and problem-solving activity that teachers wish to foster. In this study, it was found that the desire to ensure successful product outcomes prevented students from failing to produce outcomes, reduced the risk involved in the process, and thus prevented students learning from failure.

Various researchers have claimed that D & T has the potential to be a rich environment for co-operative learning (Henley & Lyle, 1995; Hennessy & Murphy, 1999). In addition, D & T is believed to be a unique subject for involving procedural problem solving activities where co-operative learning and talk between peers ‘relates to physical manipulation and feedback’, and where ‘concrete models and graphical representations play an important mediating role’ (Hennessy & Murphy, 1999). However, they go on to point out the crucial role played by the teacher in fostering this collaboration – a role which has been underplayed in research literature on collaboration. Positive
collaborative experiences mentioned include, for instance, that (intellectually) matched pairs of pupils learn better than asymmetrical pairs.

Linton and Rutland (1998) found improvements among less able children. Not only did their behaviour improve during D & T activities, but they seemed to excel in practical problem solving tasks, while practising and developing more academic skills such as measurement, speaking, listening, etc.

In contrast to these positive examples, Elmer (2002) laments the peripheral status of meta-cognition in the D & T literature (eg Eggleston, 1996, but with notable exceptions eg Lawler, 1997; Kimbell & Perry, 2001, and to some extent Hennessy & McCormick, 1994), and Atkinson (2000) discovered that high order thinking, such as creativity, problem solving and analytical thinking, impact upon pupils’ GCSE D & T performance. Results of a relatively small study of 27 pupils taking GCSE suggest that D & T is not capitalising on its potential for pupil learning because of the need for high levels of performance at public examinations which fail to reward creativity (Atkinson, 1994). Atkinson (2000) found surprising evidence that such capabilities are not necessarily required and that being highly creative could be a hindrance in terms of examination gradings.

Nevertheless, the D & T curriculum does actually provide opportunities for pupils to develop their high order thinking skills (eg creative thinking, critical thinking, analytical thinking) and problem-solving skills which they will need to participate in our technological society (eg see Lewis, 1999; Atkinson, 2000).

### 5.2.3 Raising standards of achievement
(in literacy, numeracy, KS tests, GCSE, A-levels and GNVQs)

Ofsted (2001) report that teaching of literacy and numeracy through D & T is weaker than in most other subjects in primary schools but there are some positive examples.

**Literacy**

The use of language across the curriculum is a requirement of the National Curriculum 2000. D & T contributes to this aim by developing the ability of pupils to:

- use technical terms
- clarify specifications and plan manufacture
- evaluative both the product and process (Davies, L, 2000).

Moreover, the use of technical terms and concepts for D & T are essential to effective participation in the subject. These include:

- expression of ideas
- terms relating to materials and making processes
- descriptions
- the language of evaluation.

Nevertheless, there is some suggestion (eg Parkinson, 1999) based on classroom observations of 49 children aged 3–6 years and 28 teachers, that the use of
technical vocabulary from an early age can be undesirable and specialist terminology should be delayed until secondary school, where more technically able staff can use appropriate terms consistently within relevant contexts.

Also Stables and Rogers (2001) found boys thinking and reflective skills can be enhanced by literacy interventions in D & T.

**Numeracy**

Direct research relating to the effects of D & T on numeracy was not evident. However, D & T has an obvious link with mathematics (eg see Davies, 2000). For instance, during the planning, realisation and evaluation of processes and products in D & T opportunities arise for the collection, sorting, representation and analysis of data in lists, diagrams and graphs, estimation, measurement of lengths and angles, and for calculation for drawing to scale or for the effects of loads.

**Key Stage tests**

There was some evidence of pupils performance in D & T at various key stages, but not of the effects of D & T on specific tests. For instance, Ofsted Primary Subject Reports (2002a) shows that although pupils’ achievement in D & T generally is at least satisfactory in the great majority of schools and is rated ‘good’ in one school in four, it is unsatisfactory in one school in six at Key Stage 2. Similarly, pupils’ achievement in Key Stages 1 and 2 continue to be better in making than in designing but their knowledge and understanding of the materials, components and processes that they use continue to improve steadily.

DfES provisional statistics for 2002 Key Stage 3 tests show that girls are outperforming boys in the higher grades. Seventy-six percent of girls compared to 61% of boys achieved level 5 or higher <http://dfes.gov.uk/statistics/DB/SFR/SO348/>. This was a 1% improvement for both sexes on the previous year’s findings (Statistics of Education National Curriculum Assessments of 7, 11- and 14-year-olds in England 2001, DfES, 2002).

**GCSE**

We found no research literature to show the impact of D & T on GCSE results in other subjects. However, as mentioned above (4.2.5) greater numbers of pupils have been entered for D & T GCSE examinations over the past decade, with annual improvements in the proportions of pupils attaining grades A*-C and D & T is the fifth most common subject to be taken at GCSE. In common with other subjects, girls outperform boys in GCSE D & T examinations at grades A*-C. However, there was some criticism in the literature. For example, Atkinson (2000) found that examples of highly structured, inflexible models provided by teachers (in 8 schools studied) while enabling pupils to achieve success in examinations, do limit the development of high order thinking skills.

One study that did attempt to look at transfer effects of work in technology classes to other areas of the curriculum was that of Hamaker *et al.*, (1996, 1998). Although their findings are tentative, the researchers suggest that techniques used in D & T can enhance not only D & T performance but may, in time
transfer to other subjects such as mathematics and science. We found no published evidence that improvements in technology affect English language or English literature results.

**A-level and GNVQ**

Again, we found no research literature on the effect of D & T on performance generally, but as stated in section 4.2.5 above, generally achievement in D & T is rising at a rate well above the average of all subjects (Ofsted, 2002b). Debates about change in the post-16 curriculum have emphasised the need for all students to have a broader education in the 16–19 period. Changes in participation levels and the broadening range of subjects both increase the number and range of students involved in D & T manufacturing, courses (Perry *et al.*, 1998). Where Intermediate GNVQ courses have not been available, then GCE A and AS level classes have taken on students who were not suited to learning effectively in that context. Broadening the range of students has resulted in more academically successful ones joining D & T manufacturing courses thus adding to the demands on teachers versatility (Perry *et al.*, 1998). The many problems associated with parallel systems (ie A-levels and GNVQs) have been criticised, and a unified system of certification called for (eg Kimbell, 1997).

Yeomans (1998) has pointed out that D & T is a neglected element in vocational education within the post-compulsory sector. However, it is likely that the introduction of eight new vocational GCSEs this year will have some influence on the study of D & T.

### 5.2.4 Enhancing attendance patterns

There appeared to be no published research on the impact of D & T on truancy or attendance in the UK. Although official publications (eg DfES) compared unauthorised truancy rates to authorised ones by school characteristics, there were no tables showing unauthorised absences by subject. Similarly, there were no research papers directly exploring the possible effects of D & T on improving attendance rates. Two papers relating to D & T and motivation (eg Denton, 1993; Hine, 1997) suggest that group work within D & T may make a positive contribution to pupils’ attitudes.

Kimbell and Perry (2001) mention low truancy rates in D & T reported by Ofsted. However, there is also contrary evidence from Ofsted (2001c, para 127) which suggests that where attendance is deteriorating for some disaffected Key Stage 4 pupils:

> a minority of schools were using the option to disapply part of the National Curriculum, usually modern foreign languages and less frequently design and technology, to provide an alternative work-related curriculum … Such a vocationally-oriented curriculum was not a panacea but was successful in keeping a small number of pupils, who might otherwise have been lost to the system, in touch with education and training.
5.2.5 Tackling issues of social exclusion

There were few instances of research topics related to D & T and social inclusion. (This is surprising as an explicit section on ‘Inclusion’ exists within the D & T National Curriculum documentation’s General Teaching Requirements). We identified the following:

- an example of a special educational needs in-class support which helped pupils write a D & T project evaluations (Ofsted, 2000)
- a description mentioned earlier (4.2.2) in connection with ethnicity and D & T (MacPhee, 2000)
- Linton and Rutland (1998) noted that the organised, practical problem solving experiences associated with D & T activities provide an excellent strategy for dealing with behavioural problems. This work related to a difficult Year 6 class containing many children with learning difficulties.
- Kimbell and Perry (2001) place D & T at the heart of the new citizenship agenda: ‘The activity presents teachers with a flexible tool that gives access to the many different styles and talents of the gifted, the under achiever, ethnic and gender groups or indeed any other stratification in the learning community.’

Social inclusion remains a key objective of the present Government and it should be noted that many of the aims expressed in the recent Green Paper, such as enterprise, innovation, teamwork, creativity and flexibility, are embodied in the concepts and uniqueness of D & T described earlier in this review. Elsewhere in the Green Paper it is stated that ‘the 14–19 phase must become more responsive to those with special educational needs; to those from a range of ethnic backgrounds; to those from low-income families; and to those in danger of social exclusion’ (section 1.23).

5.2.6 Cross-curricular learning

There is sufficient evidence to confirm that cross-curricular learning is recognised as fundamental to D & T activity especially in primary schools (eg Makiya & Rogers, 1992; Cross, 1998). However the effects of cross-curricular learning are less clear. Current National Curriculum Requirements (2000) indicate areas of language which are to be used in all subject teaching. However, the national strategies for literacy and numeracy appear to have had mixed effects in primary schools as they have impinged on the time available for D & T activities. But, there is recent evidence that the weaker links of D & T to literacy and numeracy reported in earlier years (eg Ofsted, 2001a) have now improved (Ofsted, 2002a, b).

Similarly, the National Curriculum requirements link D & T and mathematics, and ICT (see Davies, L, 2000). Also, within the primary sector, approximately one third of lessons have good links between D & T and other subjects (mainly art and science) (Ofsted, 2002a). Nevertheless, despite the frequent mention of art work in D & T activities (eg see 4.2.3), Howe (1999) believes that the
The effects of including D & T in the National Curriculum

fundamental connection between ‘art and design’ and ‘D & T’ has not been fully recognised or exploited in primary schools.

Over the past decade, especially during the earlier stages of D & T inception, some thought that (design and) technology and science were almost indistinguishable (eg see Gardner, 1994), especially at the primary level (see Davies, D, 1997). Yet others consider science to be a resource for technology (eg see Kimbell et al, 1996). Many science teachers have been opposed to the separate teaching of what they considered to be the ‘applied science’ of D & T (eg see Layton, 1993; Gardner, 1994; DeVries, 1996). However, between the introduction of D & T into the curriculum in 1990 and the Revised Order of 1995, the relationship between science and technology changed (Layton, 1995). Currently, the recommendations of the ‘Interaction Report’ (Barlex & Pitt, 2000) which explored the relationship between science and D & T in secondary schools, are being taken forward (see Barlex & Pitt, 2001).

The limited research relating to cross-curricular links between science and D & T has been somewhat equivocal. Levinson et al, (1997) pointed out that the National Curriculum for D & T assumed that technological conceptual knowledge and knowledge learned in subjects such as science could be used in D & T tasks. Yet, their pilot study of KS3 showed that pupils were not drawing on prior scientific knowledge for design purposes and therefore science knowledge developed in science lessons could not be readily used in technology lessons. This cast doubt on children’s ability to transfer knowledge learned in one context to another. On the other hand, this may not be such a problem, as the more usual approach in D & T is to introduce knowledge as and when needed (McCormick & Murphy, 1994).

Johnsey (1999) described a curriculum development project using a particular model of curriculum delivery in which science lessons are integrated within D & T activity to enhance learning in both subjects. Teachers thought that the closeness in time between science activities and designing and producing a product benefited pupils. Johnsey concluded that there are considerable educational advantages to linking science with D & T; however, more research into the form of the knowledge used is required (eg McCormick, 1999).

The following examples from the literature show clear evidence of cross-curricular activity.

• An immersive cross-curricular maths, science, and D & T activity was undertaken to help Year 10 students fulfil their statutory D & T allocation, motivate pupils before their public examinations, enhance the school status in the local community, involve pupils with the Technology College and enhance pupil employability (Barlex & Wright, 1999).

• A ‘packaging project’ proved a useful way to develop aspects from the PoS of other subjects (eg Till, 1996). Work with Year 3 pupils incorporated science, English, art and mathematics in order to design 3-dimensional boxes.
• Dwyer (1999) reports a mixed-age and mixed-ability group of primary children who engaged in a ‘Building Bridges’ project linked with science and geography.

• Squire and Morris, (1999) describe ScanTEK, a computer-based modular teaching programme which integrates core skills of maths, science, English and computer literacy into cross-curricular technology work.

• Harrison (2000) shows how the several strands of the discipline of engineering design develop from age 3 through to professional practice.
6: The Delivery of Design and Technology

6.1 Summary

Two questions were addressed in this section.

- How can D & T be delivered economically and effectively?
- How can D & T learning and teaching be enhanced?

The main findings are reported below.

Economic and effective delivery of D & T

- Researchers have emphasised the importance of up-to-date accommodation, equipment and materials for effective delivery of D & T. There are some examples in the literature of how D & T can be economically and effectively resourced by drawing on collaborative arrangements, outcomes from INSET courses, business and industry partnerships, and the Internet.

How to enhance D & T learning (and teaching)

- Equipment and accommodation: The consensus is that D & T requires adequate accommodation, storage, equipment, materials, software, links with business and industry, and up-to-date trained staff. Ways of enhancing D & T learning and teaching were identified in the literature. However, some current problems associated with accommodation and equipment may only be alleviated by injections of funding or increased capitation.

- Curriculum content: We found little research evidence relating to this topic. Some researchers believe that employers want skills and attitudes such as enterprise, innovation, teamwork, creativity and flexibility, all of which are associated with the concept of D & T.

- Teaching methods: Research literature relating to D & T teaching methods covered a variety of topics. Most agree that effective teaching of D & T requires a very wide range of teaching methods. The interaction of teachers with individuals, groups and whole class activities is crucial in developing pupils’ technological capability.

- Continuing professional development: Research recognises the need for teachers to engage in continuing professional development. As many primary staff still lack specialist knowledge, more training or INSET is required. A shortage of specialist teachers is also problematic at secondary level, especially in food technology and for systems and control.

6.2 The delivery of D & T

This section investigates a range of published views concerning the delivery of D & T within mainstream schools. It was not intended for this review to include details of the Specialist Schools Programme, nor specialist institutions.
themselves, such as City Technology Colleges/technology schools, although their existence and potential value is acknowledged as an additional feature of D & T delivery nation-wide. It is necessary to reiterate that the removal of D & T from the core curriculum at KS4, as proposed in the 14–19 Green Paper, will clearly have financial implications for secondary schooling. We anticipate that the Government’s desire to introduce more flexibility into the curriculum will require schools to become even more resourceful. Searches of the educational literature databases have yielded few research articles relating directly to the delivery of D & T. However, some literature that comments indirectly on the topic has been included in this section.

**How can D & T be delivered economically and effectively?**

Ofsted reports for the past few years have stressed that support from senior management remains a key factor in the progress made by schools in improving standards in D & T (Ofsted, 2002a). Inspectors note that where senior staff do not support or understand the subject, minimal time is given to D & T, there is no overall plan for the subject, and little progress is made. Approximately 16% of schools are failing in this respect. The role of the subject co-ordinator is central to the quality of D & T in a school. Problems have been associated with:

- identifying someone to take the role
- high turnover of co-ordinators
- breadth and relative unfamiliarity of curriculum
- the wide range of resources used
- reluctance of many teachers to engage with new D&T activities.

As Ofsted explained:

> effective leaders develop a coherent policy and promote progressively demanding tasks through a clearly structured scheme of work. They provide whole-school and individual INSET and support and give colleagues confidence in their teaching. Such responsibilities need time, yet only two-fifths of co-ordinators have any non-contact time to complete such tasks, particularly those involving working with colleagues.  

(Ofsted, 2002a)

**Micro level influences**

D & T researchers have also stressed the importance of senior staff in effective delivery. Benson and Johnsey (1998) evaluated the long-term effects on schools and staff of in-service courses for teachers of primary D & T. Part of this training has been through the Grants for Education and Training (GEST) funded courses which ranged from 5 to 20 days in duration. Two surveys were conducted to assess the degree of change perceived over the previous 4 years. The analysis and conclusions indicate mostly positive outcomes from these courses. The majority of respondents noted significant change in their understanding of key aspects of D & T (eg the nature of D & T and practical capability). A certain amount of positive change within their schools was also noticed since the courses. There was growing confidence with the later courses.
However, the researchers argue that it is difficult to implement change without adequate funding.

Despite having learned strategies for disseminating ideas gained on courses, a significant number of teachers found they were unable to influence other staff by INSET. Similarly, two-thirds were unable to disseminate information by teaching alongside another teacher. Benson and Johnsey recommended that:

- headteachers should be made more aware of course content, eg by involving them in initial and after-course meetings
- adequate resources should be made available (eg time and funding)
- teachers should return from courses having formulated an action plan for D & T with the headteacher, taking into account the school development plan
- more thought should be given about how to disseminate ideas after course completion
- school monitoring systems should include evaluation of the long-term impact of courses on classroom practice in D & T.

Good management of resources is also a key factor in effective delivery of D & T. With reference to the primary school, Johnsey (1998) describes how delivery of the D & T curriculum can be helped with good management of resources (ie tools, materials, suitable publications, room space etc). Furthermore, the management of resources should be overseen by D & T co-ordinators or designated senior professionals within school. They will need to:

- order and maintain materials and equipment
- organise a distribution system which all staff understand and can use
- provide advice on allocation of other resources such as space, furniture, staffing, and time
- set examples of good practice (sound teaching methods and display of children’s work).
- encourage colleagues
- co-ordinate and collaborate
- help develop a school policy for D & T – in consultation with other members of staff
- develop a scheme of work for D & T
- monitor progress of the subject within the school
- plan suitable storage and distribution of materials and equipment
- consult with head teacher, advisory teachers, independent consultants and the education authority about the subject
- be acquainted with relevant literature
- attend relevant subject courses, conferences, exhibitions
- liaise with pre-school providers etc
- join and be aware of subject associations eg DATA.
The importance of providing quality professional development, adequate time for planning and development, and implementing monitoring and evaluation procedures early in any implementation programme has also been emphasised in secondary schools (McBrien, 1996).

Denton (1994) found that simulation is a valid way of helping secondary school students to gain economic and industrial understanding. The costs of industrial visits, organising visiting speakers and work placements are high, and therefore the use of simulation can sometimes be cost-effective. Following extensive observational research in 10 institutions in which student teams created and marketed a product, students were found to be more motivated and thought the activity relevant; involvement of business/industry staff increased student response. Pupils were found to prefer the co-operative to competitive aspects of the project (even though the simulation exercise involved a financial reward).

However, Denton cautioned that the increased motivation may be a novelty effect and therefore simulation would be best used periodically, in concentrated sessions, eg by suspending the normal timetable. Such sessions help students know what they can achieve with appropriate effort, and builds self-knowledge and self-confidence. An unexpected finding was that many teachers found it difficult to stand back and allow pupils autonomy. Thus, in-service support for teachers is needed to help them adapt to unfamiliar teaching techniques. This study confirmed the value of iteration and reflection in project work. Denton felt that older students may need some help in using competition in a more positive manner.

**Macro level influences**

Gender issues are of ongoing importance. Researchers suggest that it is vital that teachers continue to foster gender neutral attitudes in the classroom, and therefore in-service programmes in gender-awareness are needed (Harding, 1997). Similarly the issue of boys’ underachievement is becoming a matter of concern. Spendlove (2001b) has suggested that fears about boys underachievement often results in a search for quick solutions, but some of these are outside teachers’ control. Teachers should endeavour to provide a gender neutral project (such as ‘environment’) or else recognise the bias and act upon it, by, for example, balancing gender stereotyped activities over a range of projects.

Kimbell (2000) considers that in the UK, despite much rhetoric about the ability of D & T to develop creative talent in the young, current management structures and bureaucracy are preventing this from being realised. The remedies he suggests relate to the main interrelated factors that influence creativity in the classroom, namely: risk, confidence and trust. He says that: ‘creative acts are inherently risky, and only confident students will take creative risks and only if they trust their teachers. Similarly, only confident teachers will take creative risks and only if they trust that those in authority over them value what they are doing. He calls for:
teachers with artistry who are trusted by their students, who have the confidence to allow them the space to take ownership of their work and develop it in unexpected ways, who have the subtlety to provide the emotional support that will encourage risk-taking; and who can (at the same time) provide the appropriate level of intellectual challenge and questioning to help the students develop their ideas.

In his polemical accusation of the ‘coercive and authoritarian governmentality’ of the past decade, he challenges teachers to take risks, but argues that space and time and encouragement is needed for such professional development.

Similarly, an overly simplistic view of the design process has been discredited by recent research and curriculum development (e.g., see Kimbell, 1991; Mayo, 1993; Hennessy & McCormick 1994; Roden, 1995; Johnsey, 1995b, 1998). Despite the rejection of a fixed process of design, separate procedural skills can be identified in those involved in designing and making (e.g., Johnsey, 1997). Researchers recommend that these should be addressed in order to deliver effective D & T principles.

The Internet is proving to be an economic and effective way of delivering the Marconi ECT programme – a programme developed by a consortium including not only Marconi but also the Institute of Electrical Engineers (IEE) (Breckon, 2001). This collaborative project promotes, develops and supports electronics and communications technology in secondary schools. This is achieved by training accredited trainers who then train teachers. Teachers receive on-going support through the website and local support groups (Marconi ECT website: <http://www.marconiect.org>). Previous experience of a pilot scheme to train teachers in electronics had been successful but costly to run (Breckon, 2001); now industrial backing from Marconi and the DTI is helping to fund the development of web-based materials (with interest and support of the DfES, Ofsted and QCA). DATA is managing the project in conjunction with TEP to ensure effective development of materials. Research has shown that students show more enthusiasm and interest in designing, making and using electronic systems when they are taught by knowledgeable teachers (see Breckon, 2001). The project aims to increase the number of teachers able to teach electronics effectively. Teachers train using the web-based materials and, in due course, these will be made available to students taking ECT courses. ECT clubs and networks are also planned to stimulate student interest.

Multimedia resources are increasingly used in teaching and learning, and could become effective tools; however, so far there is insufficient evidence of their value in D & T. Tufnell (1997) believes that further research is necessary concerning the quality of CD ROMs and the effects of using them in D & T before these are used universally. For example, to determine the effects of animation or video sequencing on users’ perceptions and the amount of information contained on a single screen.

Innovative responses to solving high capital cost problems associated with rapid prototyping technologies have been described by Lee and Todd (2001) in connection with the CAD/CAM in Schools Initiative. They suggest that others
might follow their successful example and encourage local education authorities, advisers and representatives from industry to build collaborative opportunities for students. Looking to the future, they suspect that as the capital costs fall, it may be possible to establish rapid prototyping ‘service centres’ to be shared by the education community.

Teachers clearly have a central role to play in effective delivery. A longitudinal study (Roden, 1997, 1999) of children in KS1 and KS2 traced their problem solving strategies on different D & T tasks over three years. Examination of transcripts of the work of these 36 children revealed that the children used strategies differently at different ages. It was concluded that an awareness of a taxonomy may help primary teachers to understand children’s ‘intuitive’ ways of working and so that they can offer the most useful support at the most appropriate time when guiding children through design and technology tasks in the classroom.

6.3 How to enhance D & T learning (and teaching)

This section deals with a range of factors associated with the enhancement of learning and teaching of D & T. It should be borne in mind that there are commonalities with the previous section; that is, factors that improve the effectiveness of D & T delivery are also likely to relate to improvements relating to resources, curriculum content, or aspects of teacher methods or teaching training. Also, the literature quoted here does not always point to solutions, but merely raises issues.

Ofsted D & T Subject Reports imply that the primary sector is in less need of improvement that the secondary sector.

**Primary**

For the past few years Ofsted has pointed out areas it wants some schools to address, namely to:

- improve the teaching of designing
- improve the quality and effectiveness of planning for D & T
- improve subject leadership
- develop D & T alongside literacy and numeracy.

The most recent Ofsted D & T Subject Report (2002a) for the year 2000/01 shows significant improvements in standards in the schools they visited.

- All staff have been trained in D & T.
- Pupils use a range of materials and have ready access to adequate tools.
- Teachers follow a clear scheme of work.
- Pupils are taught well the skills and the working properties of materials.
- Pupils are shown how to apply this knowledge for themselves.
Secondary
Ofsted continues to highlight deficiencies at the Key Stage 3 level of the D & T curriculum (see <www.ofsted.gov.uk/public/index.htm>). Inspectors recommend that schools:
- improve teaching of D & T
- improve standards of designing
- secure the D & T curriculum
- improve the quality of resources and accommodation for D & T.

Ofsted (2001a) suggests that design components are less sound than making skills in D & T work because ‘pupils spend too much time on superficial work associated with the presentation of their design portfolios at the expense of the main core of designing and making activities’ (Ofsted, 2001a).

6.3.1 Equipment and accommodation
This section provides details of recent and current equipment and accommodation and, if known, how these may be used to good effect. It is perhaps unsurprising that many believe that many of the current problems associated with accommodation and equipment (in particular new technology, CAD/CAM, ICT and electronics) could be alleviated by further injections of funding and increased capitation. This section details current findings and includes suggestions where applicable.

Accommodation for D & T activities is deemed poor in a third of schools and is steadily deteriorating. Lack of storage is also a particular problem. Average group sizes are also increasing, coupled with inadequately sized rooms. ‘This imposes health and safety risks, restricts pupils’ access to resources and teachers’ guidance, and exacerbates any behaviour problems; especially at Key Stage 4 where wide ranges of coursework tasks are undertaken at the same time’ (Ofsted, 2001a). Clearly not all schools can obtain immediate funding for new accommodation or refurbishment to meet the expectations of the National Curriculum, so creative organisational solutions must be sought for solving this problem.

Resources in secondary schools vary widely in quality (one-third are considered poor and a third are good) (Ofsted, 2001a). Poor quality is attributed to the inadequate capitation per pupil, which is not keeping up with inflation. (Technology Colleges appear to be faring better.)

Furthermore, the quality of teaching and learning in D & T is being affected by inadequacies in staffing, resources and accommodation. Lunchtime and after-school classes have been used as a useful means of minimising the negative effects of staff shortages, but these solutions do not solve the fundamental problems (Ofsted, 2002b).

Although some ‘hi-tech’ equipment has been provided, basic materials and teaching resources are often restricted. Similarly, despite success in training teachers in using ICT, particularly CAD/CAM, ‘the hardware resources to
embed these activities in the curriculum, as required by the National Curriculum, are often missing’ (Ofsted, 2002b). These findings were confirmed by Rutland and Pepper (2000).

Ofsted point out that in some schools pupils’ work in design has improved by using ICT in computer-aided design (CAD), although computer-aided manufacture (CAM) is less strong. Ineffective ICT use is linked to poor access to facilities within D & T departments, and pupils and teachers’ low expectations. Pupils ‘have inadequate experience of what can be achieved or how to make the best use of what is readily available’. Few pupils use ICT for control purposes in either Key Stage 3 or 4. Enhancements might be achieved by organisational changes that improve access to facilities, and training teachers in weaker aspects to increase their confidence (eg Kimbell, 2000).

During the past decade schools have been using CAD/CAM under various initiatives (eg see Breckon, 2000), although it only became compulsory at Key Stage 3, under the 2000 Orders for D & T, together with a greater emphasis on electronics and use of ICT and new materials.

ICT also has a part to play in the D & T curriculum, as many design practices in schools were drawn from industrial approaches (eg see Davies, L et al., 2000); in particular, control and manufacture; and modelling. ICT benefits students by enabling them to produce high quality outcomes, providing the means to work with repeated accuracy, facilitating batch activities and automatic control, provides workplace experiences, allows simulation of manufacturing processes, provides access to information and self-supported study, and can be highly motivating (Davies, L et al., 2000).

Using her QCA experience of discussions with teachers, Louise Davies (1999) concludes that an ideal learning environment in D & T is one where pupils have maximum autonomy and are working on self-directed projects, and where teachers are constantly assessing with pupils where they are and where they need to go. This creates complex management responsibilities for teachers to match pupils’ individual needs. Effective ways in which ICT can aid D & T learning is via self directed learning, and access to expertise. These in turn release teacher time for planned interventions and discussions with pupils. Similarly ICT can help teachers and pupils to monitor progress more readily. ICT can facilitate easier cross-curricular learning, which can motivate pupils in their individual learning. School web pages can be used for project work and assessment guides outside school hours.

However, despite many benefits of children’s use of IT in D & T, some believe that at primary level, the use of pencil and paper may be just as effective as software packages in the earlier stages of designing (Pritchard, 1997).

In 1998 the Parametric Technology Corporation (PTC) offered the UK government Pro/DESKTOP software to all schools. DATA reviewed this and recommended the software be accepted as it could stimulate schools to get involved in this work. A planned programme with integral training was implemented. DATA is the sole distributor to schools and has a team who
manage the training, software release, and monitoring. PTC provide a free license for home use, which has been of tremendous benefit to this work (Breckon, 2000).

The CAD/CAM Schools Initiative, launched in June 1999, has been providing good learning experiences. A pilot study of 413 schools, of varying degrees of CAD success, was conducted (see Breckon, 2000). Factors associated with successful schools were:

- commitment to training and investment in staff time
- the release of software for home use – provided a technician is available to advise
- teacher confidence in allowing pupils to have software (even before their own mastery of it)
- imaginative use of peers (in Years 10 and 11) to act as tutors to fellow pupils.

The main factors associated with successful CAD/CAM initiatives were:

- a collaborative effort between the DfEE, its agencies, industry, LEAs and DATA
- clear strategy and direction
- compulsory training
- enthusiastic teachers
- good publicity
- government resources
- interested and able students
- new National Curriculum requirements
- quality software packages from PTC and Delcam
- full collaboration from major equipment suppliers
- targets for implementation.

Furthermore, Breckon found that these software packages assist pupils who have poor drawing skills or lack confidence in presenting their design thinking. By contrast, CAD/CAM can also be effective with very able or perfectionist girls.

More recently, another software package called ArtCAM which complements Pro/DESKTOP (offered by Delcam) has been made available to all UK schools. Other quality CAD/CAM products available to schools include TechSoft and ROBOCAD (see Breckon, 2001). Despite successful teacher training to teach CAD/CAM, and the free provision of CAD software, many schools still find that they have inadequate access to sufficiently powerful computers; most have only basic CAM hardware and many have none (Ofsted, 2002b).
DATA is aware of the inadequate advice and resources available for teaching CAD/CAM in schools and has introduced a design awareness competition, which it hopes will help to stimulate debate. Similarly DATA is currently conducting research on the influence of CAD/CAM on teaching and learning.

In addition, for the past few years Ofsted have noted that many schools have to use industrial scrap for projects; ‘this constrains pupils’ experiences and inhibits the development of courses using more expensive components such as electronics’ (Ofsted, 2002b). Similarly, in many food technology classes pupils have to bring ingredients from home (Ofsted, 2002b). This not only risks disruption if pupils fail to bring ingredients, but it is at odds with the National Curriculum social exclusion statement. School provision of food resources could obviate this problem, which again requires a financial input.

6.3.2 Keeping up-to-date with new technology

This section seeks to explore how pupils, teachers and curriculum developers can keep abreast of the ever-changing new technologies. Technology Enhancement Programme (TEP), Royal College of Arts (RSASTD) and the Nuffield Foundation have contributed to the development of resources for use by pupils and teachers.

Pupils

Cresswell (1999) compared the relationship between D & T and industrial and commercial practices commonly used in industry. Because D & T is one of the few curriculum subjects that enables students to learn to be flexible and develop an understanding of change, Cresswell stresses the importance of new ideas, creativity and innovation in D & T. But for D & T to remain at the leading edge of the curriculum in terms of industrial and commercial practices it is important to have:

- access to up-to-date materials, ICT and the Internet
- easy access to new materials and technology
- relevant new information.

Benefits of having up-to-date resources have been reported by Squire and Morris (1999). They found that ScanTEK computer based teaching modules were excellent motivators for pupils and staff because they felt they were working at the leading edge of what could be done in the subject. Success partly resulted from a policy of encouraging access to the D & T area. Students were encouraged to use the laboratory outside lesson time to complete assignments. Teachers used the laboratory area for INSET, and interaction with other teachers created opportunities for exchanging ideas, thus raising the subject profile within the school. Financial backing was necessary, however, and system expansion was aided through local industry sponsorship.

Teachers

As was earlier stated in this report, secondary teachers nation-wide are benefiting from the accredited training programme that forms part of the
CAD/CAM Initiative in schools, managed by DATA. Similar benefits are accruing from the Marconi ECT Project, which is improving teacher expertise in electronics and communications technology (ECT). By reducing face to face teaching courses and increasing web-based content, not only is it more economic in the long term, but it will facilitate wider availability for these materials to teachers and students.

Ofsted (2002b) has found that many secondary schools are having problems in maintaining an up-to-date D & T curriculum. Mostly this relates to resource and INSET needs.

- Many teachers fail to keep up with new developments because there are few opportunities for appropriate INSET, and because access to relevant new materials etc is only just becoming commonly available to schools. (This is one of the reasons that higher ability pupils are insufficiently challenged (Ofsted 2001a).)

- In both key stages, the majority of schools has insufficient teachers with adequate knowledge of the systems and control aspects of D & T and this adversely affects their ability to teach the full range of work required by the National Curriculum.

- There is increasing evidence that teachers provide excessive coaching which allows pupils to pass through the assessment ‘hoops’ for D & T GCSE course-work at the expense of following the rationale of wider D & T learning objectives.

However, there is evidence of enhanced benefit of keeping up with new technology. Following the swift development of 'state-of-the-art' 3D CAD software in schools, and with the added bonus of a flexible licensing agreement that lets pupils install the program on their own computers, rapid progress is being made by highly motivated pupils (Ofsted, 2001a). Teachers too have built up significant expertise in this software and have developed suitable teaching materials.

This is indicative of the effectiveness of a scheme that meets teachers’ identified needs, enables them to move into modern technologies, and trains them how to use the resource with which they have been provided.

(Ofsted, 2002b)

It would appear therefore that pupils and teachers respond to state-of-the-art technologies when these are available.

**Curriculum developers**

The CAD/CAM in Schools Initiative has been welcomed as an exciting curriculum development linking ICT with D & T. In particular, Pro/DESKTOP is allowing teachers, student teachers and pupils ‘to develop computer-based simulations and virtual products, comparable with those developed by designers in professional practice’ (Lee, 2000).

The Learning Schools Programme (LSP) is a partnership between the Open University and Research Machines plc and has become the largest provider of
accredited ICT training for teachers. A commercial framework has been chosen by the present government to encourage high quality providers of training; 100 providers have been approved and schools are able to select which best meets their needs (Barlex, 2001a). These self-study programmes have been identified as having the potential to make a significant contribution to pupils’ learning in D & T (TTA, 1999).

6.3.3 Curriculum content

This section explores whether the D & T curriculum is suitable and relevant to employers and to some extent, to further and higher education, by drawing on a selection of related topics in the literature. There was, however, very little relevant research evidence relating to this topic. As stated earlier, the government is keen to improve young people’s skills to make them more employable and better citizens. Moreover, employers want ‘skills and attitudes such as enterprise, innovation, teamwork, creativity and flexibility’. All these facets are compatible with the meanings and usages of the concept of D & T as outlined in section 3.1. Nevertheless, the dearth of suitably skilled people entering the electronics industry has lead the electronics company Marconi to fund training courses (the Marconi ECT Project) for teachers to improve their electronics expertise (Breckon, 2001). As noted in the previous section, Marconi and the DTI provide financial backing, the DfES, Ofsted and QCA have an active interest, and DATA manages the project in conjunction with TEP to ensure effective development of materials. It is reasonable to assume that such strong industrial commitment combined with solid D & T educational input is likely to result in materials which are relevant to the employer stakeholders. Similarly, simulations using the Pro/DESKTOP software made available as part of the CAD/CAM in Schools Initiative are of a professional standard (Lee, 2000). One can deduce that this underlines its suitability to employers. However, Ofsted (2002) has cautioned against confusing genuine D & T capability with merely ‘the “appearance of capability” as shown by the production of sophisticated drawings’. They propose that effective ways are found of teaching students to use the software to solve design tasks. Similarly, curriculum materials need to be developed to engender creativity in pupils using new technology. Norman (1997) considers that too much variety in the GCSE and post-16 courses can be undesirable; he proposes that the curriculum should adopt a more prescribed and detailed approach to course content, partly so that Higher Education and employers can make effective use of prior learning and have some way of knowing what has been learnt.

The Royal College of Art Schools Technology Project team also foresee problems in offering a wide curriculum (Perry et al, 1998). They fear that some schools will have neither sufficient students nor the flexibility to run alternative courses side by side in manufacturing/D & T and suggest creative organisational solutions, including using a small number of syllabuses and combining different groups of students to make economic use of teachers.
Lewis (2001) explored university websites and conducted semi-structured interviews with admission/year tutors of a random sample of 14 engineering and 12 design courses in Higher Education. His findings show that A-level D & T is now an acceptable qualification for entry to engineering courses as a third A-level. Design tutors were somewhat critical of its value for entry to their courses. However, D & T A-level is a preferred entry qualification for ‘design and/with manufacturing’ courses. Some engineers were concerned that there should be a consistent body of knowledge in D & T, while others welcome D & T for entry to the study of engineering in higher education (Wright, 2003). The CAD/CAM initiatives and industrial perspectives have been welcomed but concern exists about students’ understanding of the technologies embedded in their projects. Designers are worried that the way D & T is being taught is not helping students explore creativity fully. Universities would also like to have more details of the syllabus content, especially since recent changes in A/AS levels.

Barlex (1998) highlights the mismatch between the current Examination Boards’ course work requirements and his personal ‘wish list’ that he would want to see in a student’s work. He also stresses the importance of group work in GCSE in research activity, brainstorming, reviewing progress and evaluating. Although senior designers concur with this view, this aspect is under developed in GCSE (source: GCSE D & T Focus Area Forum meetings organised by QCA: Meeting 1, 24 Nov. 1997 at Cambridge Consultants; Meeting 2, 13 March 1998 at Pankhurst Design Developments – cited in Barlex, 1998). Barlex believes that industry and commerce would welcome the inclusion of ‘group work’ on certificates.

Furthermore, Barlex (1998) questions whether a written examination is needed at all or at least whether it is important to examine across the entire syllabus. He also appeals for an assessment scheme that matches requirements of teaching designer-maker capability and technology for citizenship. Assessment methods he proffers are ‘project work’ for ‘designer maker capability’, and ‘structured questioning’ for ‘technology for citizenship’. Barlex admits that teaching technology for citizenship would require ‘a robust examination supported by appropriate training and good curriculum materials’, but is confident that good curriculum materials are already available (Nuffield case studies).

Feedback from Nuffield Area Field Officers suggests that students are being well taught, with better candidates getting better grades, but their work generally lacked flair. There is also evidence that teachers give Key Stage 3 students more autonomy in designing and making assignments than at Key Stage 4. This probably related to course work assessment requirements for KS4 (Preliminary finding of Nuffield D & T National Survey 1998 – unpublished results, in Barlex, 1998).

A small study of creativity using phenomenological methodology revealed similar findings. D & T teachers were found to be anxious about their understanding of creativity and frustrated about keeping their knowledge and skills updated (Davies, T, 2000). Furthermore, this led to teachers failing to
encourage students in the sceptical attitudes that are essential elements in the creative process. Teachers were not able to engender independent attitudes or risk-taking due to institutional and legislative requirements. Students responded by restricting themselves to ‘safe work’ that would not endanger examination success.

Kimbell (1996) is critical of what he thinks is the somewhat stultifying effects that government policy is playing in design and technology classrooms:

…the centralising influence of a national curriculum runs the risk of placing a dead weight on innovation – discouraging imaginative teachers and schools from developing their curricula. (Kimbell, 1996: 99)

Fairly similar sentiments have been expressed by Shield (1996). He criticised the implementation of technology education in the UK as being ‘distorted by political imperatives and a philosophy that has no empirical verification. Top-down implementation has led to a random approach, inflated claims for technology education and neglect of a deeper understanding of technology’. Shield calls for a deeper understanding of the professional issues. He acknowledges teachers success in developing making skills and technical knowledge, but says they should also contribute ‘to the development of strategies which lead to the elevation above the more mundane elements of the process strategy – the deeper understandings said increasingly to be at the core of our subject’.

Some (eg Cresswell, 1999) are questioning the aims of D & T; for example: ‘Should we be encouraging more designers when we have many brilliant ones that our industry fails to employ?’ and ‘If we encourage an interest in manufacturing as well as design will we enable students interested in product design to become more employable?’ Cresswell believes that industry needs innovative designers who also have an understanding of designing cost-effective commercial products. It also needs technologists who understand materials, can source them, and develop products to a price.

In addition, deficits originating in the primary curriculum may impact on D & T development. For instance, Johnsey (1997) criticised the National Curriculum for D & T (DES/WO, 1995) because ‘researching’ was not represented, ‘specifying criteria’ were absent at KS1, and ‘evaluating’ can only be effective if it is done against a clear idea of the purposes for the designed product.

As a final point, some researchers (eg Layton, 1992; Martin, 1999) argue from the position that technology is not value free. Evaluation is part of D & T. But, as students enter the adult world of technological design, values become increasingly important. Martin would therefore like to see some issues emphasised in the curriculum (eg reducing consumption, re-using products, wear and tear, maintenance, recycling etc).

### 6.3.4 Teaching methods

This section reviews D & T literature concerning classroom teaching methods that may enhance learning or teaching of D & T. Current teaching methods have
been discussed in Section 4.2.4 and literature searches presented here act as an adjunct to those already outlined.

**Primary**
The weak design compared to making activities reported by Ofsted (2001a and 2002a) is linked to the fact that teachers are less secure about designing aspects of D & T. Successful examples of teaching design noted by Ofsted include the following.

- Good teachers ensure that the design brief they set pupils prevents merely copying an existing solution.
- Short stand-alone product analysis lessons can foster evaluation and comparison skills.
- It is important for pupils to design in a real rather than an imaginary context, with a clear purpose and an actual client in mind.
- Group discussion can help develop pupils’ designing skills.

Further pointers to good D & T teaching were mentioned in the last two Ofsted reports.

- Good teachers ensure pupils develop techniques they have demonstrated or discussed.
- Planning can be improved by the use of DfES/QCA schemes of work and support materials.
- Thoughtful use of classroom assistants and adult volunteers in D & T lessons can make a valuable contribution to pupil’s achievement and progress.

D & T research literature including teaching methods covered a variety of topics. Unfortunately, although these studies provide some insight into aspects of teaching that need consideration when working with children on D & T activities, many are based on very small numbers and therefore one must interpret the findings with caution. For example, a small case study (one pair of 6-year-olds) conducted by Burgess (1998) questioned the view that children of lower attainment achieve greater success in D & T when they are working as part of a group alongside more able pupils.

Johnsey (1997) conducted extensive observations of primary children’s behavioural skills involved when they are designing and making and used these to develop a model for enhancing design and make tasks in the primary classroom. He proposed that procedural skills should be used strategically, ie appropriately selected as needed as if from a ‘toolbox’. Teachers should help pupils develop a range of such ‘tools’ and ways of combining these according to context and circumstances of the task. The advantages of this method for teachers included the following.

- It avoids the view that there is a single transferable process for designing and making.
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- It provides a basis for a set of identifiable skills which might be taught and assessed.
- Teachers can focus on a small number of procedural skills in any one assignment.
- It encourages the notion that D & T requires creativity and imagination (reflecting pupils’ personality, experience and intuitive judgements) and being free from the notion that there is only one correct way to design and make.
- It meets requirements of the National Curriculum but develops teachers’ understanding of D & T procedural skills.
- By attending to one procedural skill at a time is allows progression within each one.

Johnsey also concluded that greater recognition of the value of research activity in the primary school curriculum would enhance learning and provide a basis for design.

Other researchers have stressed that fundamental to D & T activity is the centrality of teachers in fostering critical reflection and broadening questioning processes (e.g. Stables, 1997; Jephcote, 1992).

The more young children engage in technological activity, the more their confidence in their technological abilities is likely to be established (Stables, 1997). Ritchie (1995) has highlighted three critical features of learning situations that are significant for nurturing technological capability:

- learning through practical experience
- an active learning process that lets children construct their understanding of the world
- learning within a social context.

The original APU research (Kimbell et al., 1991) revealed the iterative nature of designing and making processes, and the importance of balancing needs for reflective thinking about tasks with needs to turn ideas into working entities. These findings based on 15-year-olds have been established as equally valid for younger children (Stables, 1992a; Kimbell et al., 1996; Anning, 1994), together with the importance of developing ‘thought’ skills and ‘action’ skills in primary age children in technology (Benson & Raat, 1995).

Open-ended, but clearly focused teaching has been recommended following a cross-cultural study of D & T education (Twyford & Jarvinen, 2000). This method gives pupils wider opportunities for making connections to previous experiences and knowledge to create original and innovative designs and products. Teachers should facilitate opportunities for pupils to extend their experiences into personal inquiries for experiments as it ‘engenders the spirit of technology where pupils think like designers or technologists’. 
Even so, teachers should remember that for younger children developmental needs rather than the vocational needs of the country should remain paramount (eg Stables, 1997). It is, however, recognised that a shift in preoccupation will develop towards the end of schooling.

**Secondary**

The current state of D & T teaching in secondary education reported by Ofsted, (2002b) is generally good. The areas of weakness noted were in Key Stage 3, especially the teaching of ‘designing’ and ‘systems and control’. However, Ofsted raises the problematic issue of ‘which aspects of designing are best tackled with CAD so that it genuinely raises D & T capability rather than just the “appearance of capability” shown by the production of sophisticated drawings’. Ofsted suggest that CAD is best used in design development rather than for basic conceptual design, for which they say that pencil and paper or other forms of design modelling are better.

Louise Davies (2000) highlights the full range of thinking skills required in D & T schemes of work which teachers should help pupils to develop. Tasks that develop thinking skills in D & T include framing the task, doing a challenging task, and debriefing. Methods for developing thinking skills in D & T contexts include:

- teacher reflection on and modelling of thinking skills
- pair problem solving
- co-operative learning
- group discussion.

However, there are complex interactions occurring in groups, which teachers would be advised to keep in mind. A very small but detailed study of two 13-year-old boys working together with their teacher over 8 weeks (see Hennessy & Murphy, 1999; Murphy & Hennessy, 2001) showed that intellectually matched pairs of pupils learn better than asymmetrically matched pairs. Although it is impossible to generalise from such a small sample, teachers should be aware of the way they group pupils especially where teacher shortages are restricting subject choice and mixing a wide range of student ability in examination classes (eg Perry et al, 1998).

Although analyses have shown effective collaboration occurs during the early design stages, students’ collaboration and progress can be subsequently undermined, due to conflicting needs of pupils, teacher and client. Murphy and Hennessy (2001) stressed the need for teachers to draw on a repertoire of tasks that target different learning needs and require different time commitments. This raises considerable challenges for teachers.

Also, as mentioned earlier, McCormick and Davidson (1996) warn that where teachers allow products to take precedence over design processes or problem solving, it can prevent students learning from failure. They propose that teachers should allow more risk and some degree of failure in design and make...
assignments. While successful completion of made objects is important, the balance should be tipped more in favour of the processes of design and problem solving.

A study of teachers’ interactions with pupils in T & D undertaken in Northern Ireland (McNair et al., 2000) confirmed that this subject provides rich opportunities for higher order questions that reflect its conceptual structure. In particular, researchers suggest that pupils learn effectively by negotiating and developing meanings through teacher-pupil interactions. Consequently, these skills need to be promoted.

Pupils’ cognitive style has been shown to affect GCSE performance (Atkinson, 1998). It was found that a far greater percentage of students who are ‘wholists’ in their thinking style are adversely affected when taught by a demotivated teacher. The effect is much smaller for students, who are verbalisers or analytic, when taught by a demotivated teacher, whether or not the students themselves are motivated.

An incidental finding from Squire and Morris (1999) as a result of teachers introducing the modular teaching program ScanTEK, was that teachers discovered that best outcomes came from using a variety of teaching methods in D & T. In addition, staff specialism was important in relation to the use of cutting edge materials as pupils achieve their best from a teacher who can teach their specialism to the full and avoid trying to teach when they have limited knowledge.

In the limited number of institutions commented upon (two) Squire and Morris (1999) found that allowing pupils access to equipment outside lesson time has helped to maintain enthusiasm and has helped pupils reach new levels of understanding. This attitude would appear to relate to teacher trust, confidence, and risk taking as mentioned earlier.

Some of the APU findings relate to the need for teachers to be aware of the iterative nature of the design process that is essential while students are concurrently thinking about a task and turning their ideas into reality (Kimbell et al., 1991). Similarly, they found that confidence is an important contributor to success in D & T.

General

Phenomenological research of D & T activities (involving six students and three teachers) led Trevor Davies (2000) to conclude that teachers may be impeding creativity in their students if they themselves lacked confidence about their understanding of creativity. Teachers were frustrated about keeping their knowledge and skills updated and anxious about the need for students to avoid failure. These factors result in teachers failing to encourage students in ways that promote creativity, which in turn leads to negativity in students. Institutional and legislative requirements contribute to teachers’ desire to restrict pupils to ‘safe work’, which will not jeopardise assessment results or examination success. This research confirmed their belief that D & T teachers
must be empowered to become effective learners themselves and a better understanding of the nature of effective mentorship developed. This would promote an appropriate culture of trust and shared risk-taking.

However, teachers are not likely to change their teaching methods in isolation. Inflexible assessment methods used to judge pupils’ D & T project work has dictated the process used by pupils (Atkinson, 2000). Teachers have little control over this and solutions to bring about change lie with examination boards and the National Curriculum. However, Atkinson has proposed that beneficial changes can come from teachers developing a deeper, personal understanding of the process involved in designing ‘so they can teach pupils how to design appropriately, how to develop their thinking skills, how to portray the output from that thinking in a manner that is understandable and yet relevant to the individual process being followed’. Atkinson also believes that ‘teachers are unlikely to change their current “successful” teaching strategies at public examination stage unless pupils are explicitly rewarded with higher marks for such activities’.

Structured learning opportunities promote enthusiastic responses in both teachers and learners. In particular, handling collections (such as those in the Design Museum Initiative) in a well structured manner develops understanding of how products work, what they are made from, and develops a broader range of skills such as problem solving, observation and collaboration (Stables, 2001).

Hennessy and Murphy (1999) believe that ‘collaborative learning’ has not been sufficiently used by teachers as a method of teaching D & T. This may be related to difficulties with semantics (eg the need to distinguish between ‘learning to collaborate’ and ‘learning through collaboration’ (Hennessy & Murphy, 1999)). Collaborative learning requires continuous ‘teacher support’ (Huber & Eppler, 1990 in Hennessy & Murphy, 1999) eg via task structuring, setting agendas, and pedagogic strategies for supporting learning through collaboration. ‘Group work’ which is routinely used in D & T is not necessarily the same as collaboration.

Shield (1996) has called attention to teachers’ confusion between the ‘teaching and learning methodologies they adopt and their attempts at enhancing the children’s understanding of technological process’. Some argue that this has been a problem since the introduction of D & T into the curriculum, whereby a model of technology was translated into a teaching and learning strategy (Norman & Roberts, 1992). Shield concluded that the best solution appears to be a structured approach to teaching the technological process so that learning can be effective. Thus teachers should direct students so that they can draw appropriate conclusions and motivation from the tasks rather than to simply give them the solutions.

Cross-curricular learning is a strong feature of D & T activity. Levinson et al, (1997) have explored how science knowledge could be used in D & T lessons. Case study findings indicated that conceptual knowledge achieved in science is inappropriate to meet the procedural demands of a technology task. Co-
ordination is therefore essential, but this has considerable implications for practice within the teaching profession.

Recently the Young Foresight Initiative has piloted approaches to developing designing skills, which utilise collaborative working, designing without making, public presentation of design proposals and require pupils to design for the future using new and emerging technologies as their starting point (Barlex, 2001b). The potential of this approach to make a significant difference to current practice has been reported by the research team responsible for evaluating the pilot (Davidson, Lunn & Murphy, 2002).

6.3.5 Teacher Training: Continuing Professional Development

Non-contact days were introduced as part of a national policy in England and Wales in 1988. This section will focus on examples found in the literature of suggestions for successful INSET training.

Ofsted (2002a, b) found that although teachers’ knowledge of materials, ingredients, tools and equipment is adequate for Key Stage 1 pupils, many staff lack specialist knowledge or have too low expectations of pupils’ D & T potential, particularly for older pupils. This was especially true of those teachers with few opportunities for INSET.

Low recruitment of trainees to initial teacher training courses for D & T is more acute than for any other subject with one school in six lacking suitable specialist D & T teachers (Ofsted, 2001). A similar lack of technicians often means that teachers spend too much time preparing materials and maintaining equipment rather than teaching. At secondary level, the shortage of specialist teachers, particularly for food technology and for systems and control, is now acute, especially in some parts of the country, and is depressing pupils’ attainment.

It is well documented that after the inception of D & T into the curriculum many teachers received insufficient training or help with planning what they were to teach (Hendley & Lyle, 1996; Davies, D, 2000) or how pupils knowledge should be developed (Levinson et al, 1997). However, the Nuffield Project was aware of this from the inception of D & T and that there would be a great demand for support and continuing professional development. To this end it provided teachers with published materials, organised countrywide meetings, appointed field officers to help schools use their materials etc, and produced a termly newsletter (UpDaTe) (see Barlex, 1998b). The role of these materials has been evaluated (Givens & Barlex, 2001a) and the research evidence suggests that while most teachers made at least some use of all the various components of the publications, they were selective. The study guide was underused, yet those teachers who did use it perceived greater ‘value added’ by the materials to the quality of pupils work, their effectiveness in D & T, and their autonomy.

Louise Davies (1997) investigated the use of non-contact days for D & T training. She argues that all staff development should be seen as adult education, and lists a range of examples, of how effective adult education is to be achieved, based on a variety of sources (eg Whitaker, 1993; Brookfield, 1988; Connors,
1991; Jarvis, 1983; Rogers, 1986; Sellars, 1994). These features formed the basis for a questionnaire (sent to 14 schools in 1996) to determine teachers’ perceptions of the way staff development is conceived, planned and managed in their schools. Her conclusions, suggest that it is vital to:

- recognise teachers as adult learners
- provide adequate time and funding for D & T focused INSET
- maintain an appropriate balance in the use of non-contact days for effective whole school and departmental INSET
- provide appropriate D & T INSET resources for staff teams.

Furthermore, Davies noted that most satisfaction with professional development related to:

- effective INSET planning and implementation
- the balance of time allocation, eg to whole school, departmental and individual issues
- activities that provide opportunities for collaborative, reflective, active, and hands on experiences-based on classroom and school realities, and supported by external consultants and team members where needed
- sufficient funding and flexibility to respond to needs.

Examination of the long term effects of in-depth, long-term INSET in electronic systems within D & T (eg Branson, 2002) have lead to the following recommendations for effective teacher professional development:

- detailed needs analysis – as identified by teachers
- a collaborative and practical course designed to meet these needs
- time for colleagues to work together during and after the course (networking)
- monitoring and evaluation of the effects.

In addition, Branson suggests that distance learning via the Internet will require even more rigorous application of any professional development management cycle used.

Todd and Hermit (1998) run INSET for teachers at Sheffield Hallam University. They believe that to do justice to pupils, teachers must keep abreast of new developments and update the curriculum accordingly. But teachers must be given ‘the time, resources and a fertile learning environment in which they can contemplate, experiment and learn from each other’.

Attempts have been made to provide tools that enable teachers in training to reflect on their practice (Banks & Barlex, 1999; Banks et al, 2000). These can be applied to continuing professional development with regard to departmental organisation (Barlex in Eggleston (ed) 2000).
Studies of professional development in Canada and the UK (Welch et al, 2001) revealed that a combination of approaches in a variety of contexts may be the best way to create substantial changes to teachers’ thinking and practices in terms of their pedagogical and subject knowledge.

Benson and Johnsey’s (1998) evaluation of the long-term effects on schools and staff of in-service courses for teachers of primary D & T found that most teachers noticed significant changes in their understanding of key aspects of D & T. Some positive change was also noticed within schools after the courses. However, change requires adequate funding.

Although teachers learned strategies for disseminating ideas, significant numbers were unable to put these into practice back in schools. Benson and Johnsey recommended:

• headteachers should be made aware of course content.
• adequate resources should be made available.
• teachers should return from courses having formulated an action plan for D & T with the headteacher, taking into account the school development plan.
• more thought should be given to dissemination of ideas after course completion.
• school monitoring systems should include evaluation of the long-term impact of courses on classroom practice in D & T.
7: Gaps in the Research Evidence: Conclusions and recommendations

7.1 Summary
This section identifies gaps in the research evidence emerging from this review and recommends topics which we think would aid the future development of the D & T curriculum, teaching and learning.

Main conclusions and recommendations
Our general conclusion is that despite the number of references to D & T identified in the literature mainly from the community of practice, few are research-based in terms of meeting peer-review standards. 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.

Specific issues which merit consideration are as follows.

• Can a model of research for D & T, which includes ‘users’, be developed and funded?
• 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 development of higher level skills?
• 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?
• How do good/effective teachers teach D & T, organise their classrooms, workshops, and equipment, access resources and how do they keep up-to-date?
• 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 do employers in industry/business want from D & T and how can productive relationships with these be extended?
• Do up-to-date resources impact on pupils achievement?
• 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 curriculum at Key Stage 4.
7.2 Further research and recommendations

7.2.1 Type of research

As reviewers we were impressed, and somewhat overwhelmed, by the number of references to D & T in the literature mainly produced by the community of practice. Within the time constraints within which this review was undertaken, we could not hope to do justice to this large volume of work and, therefore, imposed our own rather more limited criteria for inclusion. The review is based primarily on research which has been peer-reviewed for publication in academic journals or published in research reports. This device excludes much action research and also curriculum development undertaken by the ‘user’ community. We have, however, included evidence from Ofsted reports in order to provide a national picture of the delivery of D & T.

We acknowledge that action research has a well-established contribution to make to practice (Stenhouse, 1975). More recently Barlex and Welch (2001) have highlighted the importance of collaboration between education, research and curriculum development in D & T. More generally the role of the ‘end-user’ in educational research has been recognised. For example, the ESRC’s current Teaching and Learning Research Programme makes involvement of users a necessary condition of grant <http://www.tlrp.org>; and for several years as part of its Service Level Agreement with the Scottish Executive, SCRE has organised a Teacher (now Practitioner) Researcher Network <http://www.scre.ac.uk>. In England, The Teacher Training Agency also makes small grants available to teachers who undertake practitioner research with support from HEIs. Theoretical justification for the involvement of teachers in research is provided by Hargreaves (1998), who describes a ‘knowledge creating school’ as one which investigates the state of its intellectual capital; massages the process of creating new professional knowledge; validates the professional knowledge created and disseminates the created professional knowledge. Therefore, the fact that we found little peer-reviewed research in D & T is no reflection on the activities being undertaken by practitioners. It is more likely to be related to the amount of research funding and/or interest of professional researchers in this topic area. Specific topics identified by researchers in the papers we reviewed are listed in section 7.2.2 below.

7.2.2 Specific points from the literature

This section highlights some of the requests for further research that researchers, whose work we reviewed, believe will contribute to the development of the D & T curriculum, teaching and learning. Some have argued (eg Kimbell, 1996; Atkinson, 2000) that the inflexible assessment methods used to judge pupils’ D & T project work has dictated the processes used by those pupils. Atkinson (2000) proposes changes that she thinks would improve the current situation. One of her suggestions is that ‘the National Curriculum documentation needs to incorporate a more effective means of encouraging teachers to use appropriate strategies which are less formulaic in order that the perceived importance regarding the stages of the process of designing do not outweigh the thinking that takes place’. More research into the area of effective learning and teaching of D & T is clearly required.
In addition more research is required on the role of ICT. Weaknesses in designing activity led Ofsted (2002b) to suggest that more work needs to be done to discover the most effective ways of teaching pupils to use computer software to help them in solving design tasks. Suitable curriculum materials need to be developed that foster creative responses from pupils using these new designing and manufacturing resources. These findings highlight the need for further research into the impact of assessment on design and the use of ICT. In addition, research is clearly needed to explore how design might more effectively be encouraged within D & T.

DATA is aware of the inadequate advice and resources available for teaching CAD/CAM in schools and has introduced a design awareness competition which it hopes will help to stimulate debate. Similarly DATA is currently conducting research on the influence of CAD/CAM on teaching and learning. Further research on this area is needed, especially as there are considerable economic issues involved in the effective use of ICT.

Hennessy and Murphy (1999) have been critical of D & T research and call for more classroom-based research to explore the role of collaboration in facilitating technological problem solving rather than the teacher-led problem solving which they claim is typical.

The finding that intellectually matched pairs of pupils learn better than asymmetrically matched pairs (Hennessy & Murphy, 1999) needs further exploration as this has important implications for group work in mixed ability classes. Observations that some children are inhibited from showing what they know or from developing their skills when in the presence of more able children, yet are more encouraged by working with children whom they can help, points to the need for further investigation (Burgess, 1998).

Denton (1994) has also criticised D & T research, and has called for appropriate methodologies that recognise the difficulties in separating out the variables in live learning situations – a problem shared with other curricular subjects.

Anning (1994) has demonstrated that D & T in the primary school provides a learning environment which highlights children’s previously unnoted capabilities and deficiencies in areas such as graphicacy, evaluation processes, and manipulation of tools. However, much more research is needed in order to substantiate these claims.

Shield (1996) considers that many of the problems associated with D & T were related to the fact that a complex curriculum was introduced via a top-down strategy, and he believes that a deeper understanding of the professional issues is required. Essentially, he argues that having been told what the concept of D & T means by those introducing this new subject into the curriculum, teachers are endeavouring to make this a reality. In 1996 Shield was pressing for researchers to test the validity of the claims for the capabilities developed within the D & T curriculum, saying:

*the most basic requirement would appear to be some verification that the proposed changes can deliver what is claimed for them not only through*
a theoretical overview … but also grounded upon a planned program of empirical research. Furthermore this research must reflect the scene in our average schools and not merely reinforce the practice of enthusiastic experts working in atypical environments … Claims are being made that technology education within our schools is instrumental in enhancing problem solving skills, craft skills and knowledge, aesthetic awareness, graphic and wider communication skills, social awareness and team work (including combating racial and gender prejudice), scientific and technical literacy, industrial and economic understanding, environmental activism, “life skills” and vocational training. This litany of virtue smacks of protesting too much, to the extent that it makes one wonder what the rest of the school is doing.

7.3 Conclusion and recommendations

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 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 core at Key Stage 4.
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[http://www.leeds.ac.uk/educol/documents/00001316.htm]


Design on the Curriculum?


Pritchard, A (2001) Computer control in Key Stage 2 design and technology: Massed or spaced, which is best? The Journal of Design and Technology Education, 6 (2) 139–144.


Wright, R (2003) Private correspondence with the authors.

### Appendix 1: Search strategy

<table>
<thead>
<tr>
<th>Appendix 1: Search strategy</th>
<th>British Education Index</th>
<th>ERIC</th>
<th>PsychInfo</th>
<th>CERUK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 “technology education”</td>
<td>909</td>
<td>1092</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>2 design (and OR &amp; technology)</td>
<td>388</td>
<td>3</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>3 1 OR 2</td>
<td>654</td>
<td>1094</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td>4 3 AND (age* OR stage*)</td>
<td>32</td>
<td>84</td>
<td>6</td>
<td>&lt;12</td>
</tr>
<tr>
<td>5 3 AND (“national curriculum”)</td>
<td>139</td>
<td>26</td>
<td>2</td>
<td>&lt;12</td>
</tr>
<tr>
<td>6 3 AND (gender OR sex)</td>
<td>24</td>
<td>61</td>
<td>10</td>
<td>&lt;12</td>
</tr>
<tr>
<td>7 3 AND (disab* OR (special WITH needs))</td>
<td>12</td>
<td>29</td>
<td>3</td>
<td>&lt;12</td>
</tr>
<tr>
<td>8 3 AND (ethnic* OR race OR racial)</td>
<td>2</td>
<td>13</td>
<td>0</td>
<td>&lt;12</td>
</tr>
<tr>
<td>9 3 AND ((social (inclusion OR exclusion)) OR (economic* disadvantage*) OR poverty)</td>
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<td>5</td>
<td>0</td>
<td>&lt;12</td>
</tr>
<tr>
<td>10 3 AND (attainment OR achievement OR outcome* OR result* OR examination*)</td>
<td>31</td>
<td>194</td>
<td>16</td>
<td>&lt;12</td>
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<tr>
<td>11 3 AND (literacy OR numeracy OR ((key OR core) skills) OR “cognitive development”)</td>
<td>19</td>
<td>166</td>
<td>2</td>
<td>&lt;12</td>
</tr>
<tr>
<td>12 3 AND (truant* OR attend* OR motivat*)</td>
<td>4</td>
<td>52</td>
<td>8</td>
<td>&lt;12</td>
</tr>
<tr>
<td>13 3 AND ((cross OR across) WITH curricul*)</td>
<td>11</td>
<td>8</td>
<td>0</td>
<td>&lt;12</td>
</tr>
<tr>
<td>14 3 AND (employ* OR work OR business OR industr* OR vocation* OR profession*)</td>
<td>92</td>
<td>376</td>
<td>12</td>
<td>&lt;12</td>
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<tr>
<td>15 3 AND ((out WITH of WITH school) OR (extra WITH curricular))</td>
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<td>9</td>
<td>0</td>
<td>&lt;12</td>
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<tr>
<td>16 3 AND ((teach* (method* OR approach*)) OR (curriculum WITH delivery) OR pedagog*)</td>
<td>25</td>
<td>121</td>
<td>8</td>
<td>&lt;12</td>
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<tr>
<td>17 3 AND (“continuing professional development” OR “CPD”)</td>
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<td>35</td>
<td>0</td>
<td>&lt;12</td>
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<tr>
<td>18 3 AND ((new WITH technolog*) OR “CAD” OR “CAM” OR “ICT” OR electronics)</td>
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<td>117</td>
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<td>19 3 AND (resource* OR fund* OR financ* OR econom*)</td>
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<td>241</td>
<td>7</td>
<td>&lt;12</td>
</tr>
<tr>
<td>20 3 AND (able OR gifted)</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>&lt;12</td>
</tr>
</tbody>
</table>