Designs on the Curriculum?
A Review of the Literature on the Impact of Design and Technology in Schools in England

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Executive Summary
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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 nonverbal 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 interrelationship 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.

* *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, Alevel 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.

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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.

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