Factors effecting design and technology capability at Key Stages 1 and 2

Angela Anning
School of Education, University of Leeds

Eighteen months after the introduction of a National Curriculum version of Design and Technology we are beginning to gain insights into the actual rather than theoretical design and technology capabilities of children up to the age of 11. The Attainment Targets set out in the Order introduced at Key Stages 1 to 3 in September 1990 were of necessity based on inspired guesswork. There was little empirical evidence of what young children could do, other than from case studies of primary classteacher 'enthusiasts' who had shown an interest in craft, design and technology.

It is not possible to study capability independently of the context in which it takes place. Context is not simply 'a nuisance variable' but rather 'an integral aspect of cognitive events' (Rogoff and Lave, 1988). The settings in which the events take place, the role of the actors — teachers and pupils — and the value systems underpinning their behaviours with all have an effect on what children can do. In the Foreword to the Consultation Report (NCC, 1989) Technology was defined as 'the one subject in the National Curriculum that is directly concerned with generating ideas, making and doing'. It was seen to have an important role in providing a balance in a curriculum based on academic subjects — 'a balance in which the creative and practical capabilitiesc of pupils can be fully developed and inter-related'. The group also drew attention to the 'real world' implications of technology education in training pupils for 'the employment needs of business and industry. In the era of Thatcherism this accounts for the astonishing speed at which technology was introduced as a foundation subject.

Design and technology was defined by the Working Group as 'a unitary concept, to be spoken in one breath as it were' (1.6). This allows it to sit uneasily between the very different conceptual and pedagogic traditions of the arts and science lobbies. In some versions of the strategic models of the Order adopted by LEAs and schools, science dominated the culture of the documentation and training. Other LEAs veered strongly towards art and design aspects of the subject. Such macro-level value systems had implications for the ways in which the Order was operationalised in schools.

□ The school context

At a micro-level each school took ownership of the Order with varying degrees of commitment/resentment. In September 1990 we interviewed advisers, headteachers, teachers, and technology co-ordinators in two LEAs within a small scale research project designed to monitor the implementation of Technology 5 to 11, based at Leeds University School of Education. Not surprisingly, since for many of them design and technology was perceived as a 'new' subject, they had interpreted the Programmes of Study in ways that fitted in with their school or personal strengths and traditions. When we asked them what they understood by technology they referred to art and design — 'a process of thinking and planning and problem solving, which is about design awareness and re-designing, which is really art and 3D work'; environmental studies — 'giving children opportunities to have practical ways of expressing their place in the environment and their awareness of their own environment'; and craft work — 'the old craft heading —

making 3 dimensional objects, making working models'; or 'box modelling, making masks, puppets etc ...turning the house corner into a shop or something like that'. As one teacher put it, 'We've always done it. It's just got a new label hasn't it?'

For the largely arts based female dominated work force, the content of the National Curriculum document was seen as alien to their culture and concerns, and the language intimidating and inaccessible. Some had also recognised that the complex model of teaching and learning implicit in the message within the Order to consider the four attainment targets within a holistic framework, marked this curriculum out as different from the English, Mathematics and Science Orders. One teacher described the difficulty she had in 'holding it all in her head' and went on to explain 'I keep reading it and going back to it and it's a fact that you can't just dip, which I think you can do with the other documents ...you have to hold on to and understand the whole thing.' They felt anxious about teaching the subject, about their own lack of knowledge and expertise in technology, about the safety aspects of children handling unfamiliar tools and equipment, and about the costs of resourcing a new area of the curriculum from scratch. Despite their efforts at 'self-help' Baker Days and the LEA attempts to provide in-service for them, they reflected the views of the depressingly low figure of one in seven of a national sample of 900 primary teachers surveyed in a Leverhulme Project (Wragg, 1991) who felt competent to teach technology.

Despite their misgivings, most of the teachers were planning to incorporate design and technology within the topics they had planned for the Autumn term. We went back to four of the twelve schools we visited to observe and record (using audio and video tape, field notes, photographs and photocopies) children in Years 1 and 3 (the beginning of the two key stages) on tasks defined by their teachers as design and technology activities. After further discussions with the teachers, we returned to these classrooms in the Summer term of 1991 to observe the same children working on tasks we had designed to explore aspects of capability that particularly interested us after our analysis of the initial data.

Figure 1 summarises three domains of capability and features within those domains. The model forms a framework for discussion for the second section of this article.

Figure 1: Domains of design and technology capability at Key Stages 1 and 2

Pupils should be able to:

1. **Identify needs and opportunities to generate a design**	2. **Plan and make**	
Identify problems, process information and visualise solutions **BY** — imaging (running mental models through the mind's eye) — describing emergent ideas in words (a) talk (b) writing in graphic form (a) sketches (b) diagrams in models	**HOW** Find ways to organise and carry through emergent ideas **BY** adopting — strategies (a) systematic (b) ad hoc (c) working alone (d) working collaboratively — tactics (a) referring to instructions (b) talking aloud — self regulatory — to peer group — to adult (c) observing/imitating others (d) experimenting with materials and tools (e) seeking out information specific to task from books, photos, diagrams etc. (f) asking questions/seeking advice.	**WHAT** Refine external equivalents of internal models into an outcome **BY** — choice of materials representation — decision to go for open-ended investigation — decision to make a pre-conceived end product (a) scale model (b) prototype (c) detailed presentation of a design idea — rearranging, refining or replicating a system — producing a verbal/written/ drawn presentation of proposals for a planned change to an environment.
3. **Evaluate**		
Talk about ideas. Synthesise into possible solutions.	Acknowledge and work within constraints Modify work in progress.	Appraise the outcome through discussion, reflection and testing.

FEATURES

☐ Design and technology capabilities

☐ 1. Identifying needs and opportunities to generate a design

When we asked the teachers about their expectations of what children might achieve in design and technology, how they planned to ensure progression in learning and how they intended to assess levels of attainment, they were understandably defensive. Their knowledge of the content of the programmes of study and the levels within the statement of attainment was still sketchy. Attainment Target 1, Identifying Needs and Opportunities, particularly vexed teachers. They were not clear if individual pupils should be left to 'discover' design and technology opportunities for themselves or if the teacher should 'structure' them. This uncertainty reflected the opposing ideologies of 'child-centred' versus teacher directed learning which have been a feature of primary education for so long.

In the model in Figure 1 we have chosen to link AT1 with AT2, Generating a Design. We observed these skilful teachers intuitively using a range of strategies to get children started on the processes of identifying needs and opportunities within either a specific task such as making a model of a building site machine or some more broadly based activities such as setting up a cafe. Ideas might be generated with the whole class using a brainstorming technique — listing ideas on a flip chart or board — and reviewed at the end of the session. Frequently children were then expected to move straight onto generating a design. But we observed brainstorming techniques being productively extended within small group discussions. Conflict in resolving the opposing views of children could be used much more creatively when the teacher did not have to worry about controlling the class. Detailed discussions between pairs of children about a design proposal could also be very productive.

It was difficult for the *children* to appreciate what a valuable investment this thinking time would prove — they mostly wanted to get on task as quickly as possible! But it was clear to us as observers that talking time *was* productive. Perhaps we should make this more explicit to the children by pointing out to them how critical 'nodal points — points that is at which the learner's understanding undergoes a metamorphosis' (Liddament, 1991, p.103) were often embedded in talk with others. It is as important to teach the procedural skills of designerly thinking as it is to teach the practical skills and there is research evidence that children's awareness of learning how to think can be raised at nursery age (Weikart *et al*, 1978).

☐ Imaging

When children were imaging, running mental models through the mind's eye, the scaffolding provided by a thoughtful teacher can enrich this process immeasurably. Children's ability to image must be dependent on a store of alternatives mental models related to previous exposure to and experiences of similar things, So, for example, if children are asked to design a shelter for a pet, one of the Key Stage 1 optional SAT activities, the teacher needs to collect together, with the help of the children, many images and sources of information-photographs, drawings, video recordings, information books, real objects such as nests, cages — and to arrange visits to, for example, a pet shop or local/urban farm. The form and function of shelters, as well as the materials used to make them, need to be experienced and at least partially understood. When children are asked to invent their own design for a pet shelter, they can then draw on this store of mental images and can function at a much higher level.

☐ Describing emergent ideas in words

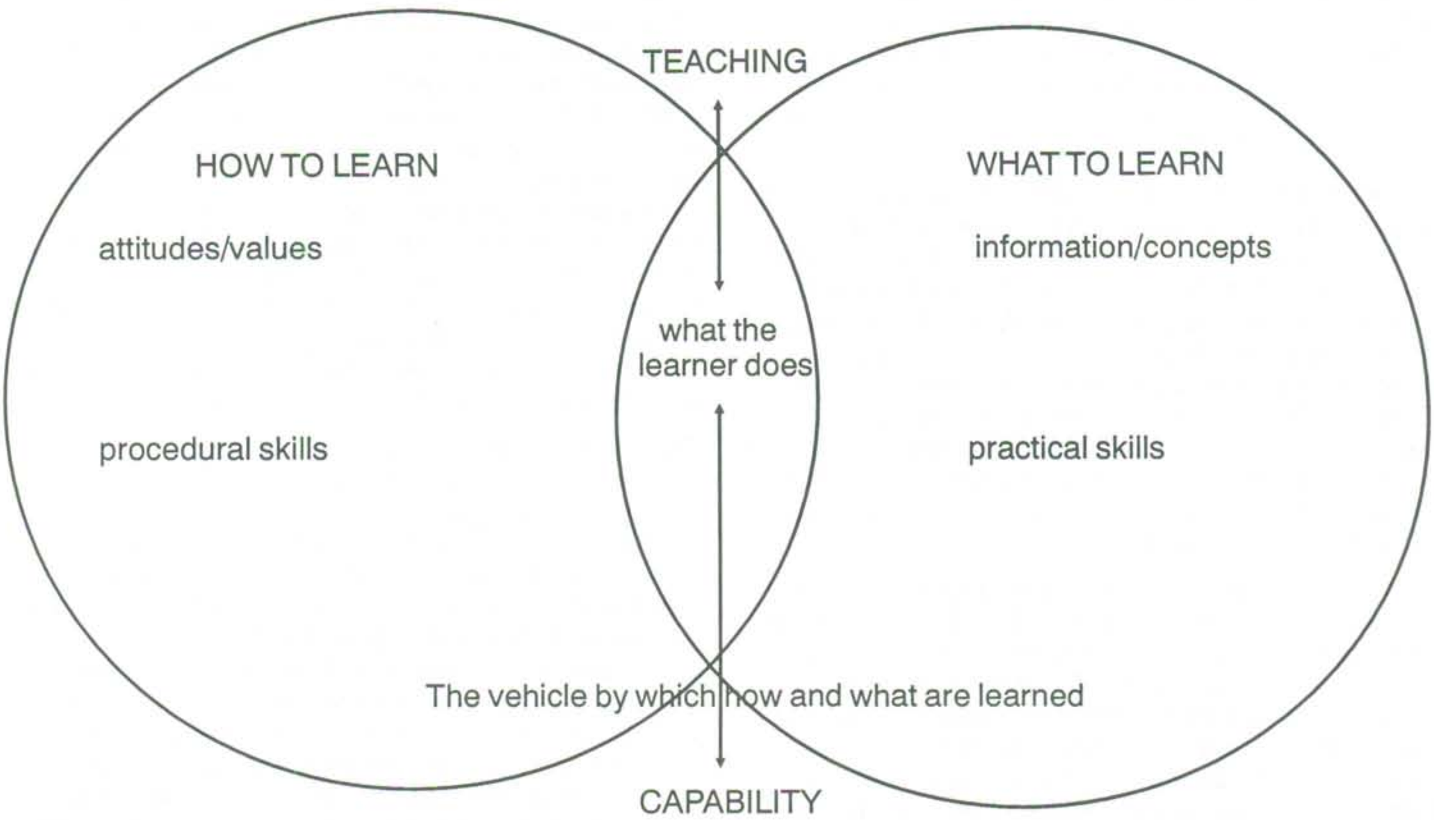
The way in which children begin to describe their emergent ideas is another feature of capability that needs to be understood and resourced by teachers. The value of talking through ideas has already been stressed. We also observed children using writing to formalise their thinking. Where children were asked to design a clock, their writing was structured by a series of questions written on the board about the parameters of the design decisions — Where is it going to go? Who is it for? What materials will you use? Size, shape and colour? Hands, numbers, date? How will it be powered? Will it hang on the wall or stand up? Children were encouraged to make lists of equipment or resources they would need before they began an activity. These advance organisers were useful for many children. But we observed others, whose ability to write lagged behind their ability to image, frustrated to having to go through a writing exercise before they were allowed to move on to practical work.

☐ Describing emergent ideas in drawings

An alternative to verbalising emergent ideas is to present them in graphic form. The teachers we interviewed were aware of the possibilities of using drawing as a medium to express thinking, but were uncertain whether young children were able to match their imaginative abilities with representational skills. One infant teacher said, 'I don't think they need to draw and plan it at 5. I think they want to make it first and possibly record and draw about it afterwards. They don't know what it looks like before they make it. To see it before you've done it, that's hard.' In fact we observed children translating highly imaginative images into elaborate drawings in infant and junior classrooms. However, their drawings bore little relationship to anything they could make! The problem seems to be that we simply confuse children by not making explicit the various conventions that are available to them for using drawing as a tool for both clarifying and recording ideas. It is a useful skill to be able to record the kind of narrative fantasias at which many children excel. Sometimes making such a drawing can be a valid design exercise in its own right — graphic designers often earn a living through this mode of graphicacy. But there are alternative modes of drawing which children need to learn.

Children have often absorbed an unstated rule that drawings should result in a perfect product — despite the fact that in many classrooms drawing is seen as a servicing agent or time-filler after the more important activities of literacy and numercy have been completed. When we asked some children to 'scribble' a few ideas down for hamster exercise equipment, they were horrified. We should have recognised

Figure 2



that scribbling is a no-go area in the lives of many young children! Yet the notebook of designers are full of scribbles. Watching them work, it is fascinating to see how they move from a wandering pencil to a computer screen, from lines to words, from prototypes back to the notebook scribbles. Children need to be shown examples of how this process works. It is not surprising that they are unaware of the power of 'scribbling', since our system of education deprives them of opportunities to express their ideas in this alternative mode.

It is not necessary for teachers themselves to be able to draw, but they can resource children's designerly thinking by collecting a whole range of types of drawing used by designers — real architects drawings, copies of computer aided designs for cars, engineering drawings of basic tools, exploded diagrams of botanists — the list is endless. Children can then be encouraged to make 'technical drawings', with a clear sense of the materials they plan to use. At its simplest level this can mean asking a five year old to draw the materials she plans to use for a task — string, boxes, glue, card etc — and perhaps make an annotated drawing, with notes about how components will fit or be fixed together etc., as a second stage of recording her plans.

☐ Describing emergent ideas in models

If there are learners who work best through verbalising, and some who work best through visualising, there are also those whose natural tendency is to work kinesthetically, that is by physically manipulating materials. We observed many examples of children designing as they did. The Technology Working Group acknowledged that 'With pupils at Key Stage 1 their experience of working with materials will often be the starting point of design and technological activity' (NCC 1989, p.86). For young children the processes of actually working with basic materials such as blocks, sand, clay or recycled materials can often generate designerly thinking and understanding of the properties of materials. This leads us to the second domain of capability identified in Figure 1, planning and making.

☐ 2. Planning and making

The teachers were grappling with the pedagogic implications of the Technology Order. They wanted to allow children to experiment freely with ideas and materials, espousing art and design education traditions. Yet they were uncomfortably aware that, in order to be able to function creatively in design and technology, the children needed a set of practical skills and also a technical knowledge base. They were unsure how much technology should be 'caught' and how much 'taught'. Figure 2 illustrates a model of teaching and learning in technology.

Teachers need to be clear that teaching and HOW components of capability is of equal importance as teaching the WHAT.

☐ The how of planning and making

The teachers were unsure about teaching and monitoring the how aspects of planning and making. They were only free to pay sporadic attention of what the children were doing in design and technology. Inevitably perhaps, because practical

work in primary classrooms has traditionally been conceived as something that children can be 'left to get on with', most teacher attention was on seat-based literacy, numberacy and scientific activities. Some teachers were beginning to plan days when they freed themselves to focus exclusively on design and technology. Others were training parents helpers and NTAs to work with groups of children.

The *strategies* children used in tackling tasks depended partly on personality factors. Some worked in an orderly and systematic way. Others used trial and error. Some wanted to work alone. Others chose to work with friends. Teachers need to be sensitive to these preferences. We are not in the business of changing personalities. Yet if a child is becoming frustrated by adopting regularly strategies where they are failing, or allowing others to dominate all decision making, then the teacher should raise the children's awareness of what is happening and offer alternative strategies. Inappropriate strategies resulted in depressed levels of capability for some of the children we observed.

Some children were more skilful than others in the use of *tactics* to achieve what they wanted. They knew how to take advantage of the support mechanisms on offer — asking help of a more knowledgeable or skilled pupil or adult when in difficulty, knowing when and how to consult reference books, referring to skill cards or worksheet instructions when they needed to. It was only when the teacher was (a) aware of these different tactics and anticipated needs in the resources they provided and (b) on hand to model the use of the resources — by looking for information in books themselves, by showing children how to consult a skill card for technical information — that all the children were given support to learn or improve these aspects of capability.

☐ The what of planning and making

The vocabulary of the programmes of study was new to primary teachers. They struggled with definitions of an artefact, system or environment and to plan for the variety of materials and contexts they were asked to cover. Much of the commercially produced support material, written at speed and often by authors with backgrounds in technology or science, but not in primary education, offered unhelpful models of unrelated , one-off activities. The new Inset guidelines from the NCC (NCC, 1991) offer advice about pursuing *strands* though statements of attainment, for example those dealing with energy, as a way of planning for progression in what is attained.

At this early stage teachers were incorporating tasks within a topic or simply responding to opportunities arising from children's interests or enthusiasms. Five year olds were encouraged to experiment with a range of materials — Lego, paper structures, large blocks, clay — on tasks loosely designed to explore the concepts of the topic Up and Down. The children simply adapted tasks set by the teacher to make what they wanted! Nevertheless, they *were* all learning how to manipulate materials and tools. In a Year 3 class three girls worked over a period of days on a self-chosen task of making a model traction engine, following a set of instructions they had discovered in a library book.

Some tasks were explicitly designed by teachers for the acquisition of practical skills or technical knowledge. A whole class of Year 3 children were given one to one instruction on how to use a hand-drill, and then required to demonstrate the skill in making a small board game with holes drilled for wooden pegs. This was one of many episodes where we observed children struggling to handle unfamiliar equipment. The pistol grip drills were difficult for the children to apply pressure to at junior school table heights. We also saw many variations on children struggling with saws, benchhooks and clamps. We need research into hand/eye co-ordination, children's heights, and tool design. In a Year 1 class children were all taught the same techniques for fixing axles to a chassis and then encouraged to apply this knowledge to designing and making a model vehicle.

The purposes of other tasks was not made so clear. There was often confusion for example about whether children were making a model, a prototype or a real artefact to be tested by use. Sometimes the lack of clarity did not seem to matter. Children invented their own purposes and got on with achieving them. They were often drawn to novel materials — particularly glitzy fabrics or interestingly shaped boxes — and sometimes these were not suitable for the product the child was trying to make. A pump bag made of shiny fabric proved almost impossible to sew. A child working on a model of a space machine insisted on using a hexagonal cheese box for a cabin despite the fact that it was out of scale with the rest of his design. In other episodes learning became aimless and unproductive because instructions given by the teacher were so vague — for example, make something to live in.

In the NCC guidelines (NCC. 1991) a useful distinction is made between *resource tasks* — designed to help pupils to acquire the knowledge, understanding and skills necessary for capability in D&T — and *capability tasks* — designed to provide pupils with opportunities to develop and demonstrate capability in D&T. If teachers could get into the habit of doing a task analysis — pulling out from a central task like, for example, designing and making masks for a dance performance, the component parts of the activity and the knowledge and skills needed to achieve them, they could plan a sequence of activities building up to making the masks. These might include looking closely at the materials and construction of some real masks, looking at books and illustrations of masks used in dance performances, experimenting with movement with a variety of mask prototypes to find out which designs were suitable to leave the body free for dance. They could also set up a workshop area where children were free to experiment with card, fabric, papier mache, modroc, string, fixing devices to make prototype masks. Finally, the decisions about making masks for the actual dance performance — the capability task — would be made on the basis of knowledge and skills gained through the resource tasks — probably extending over half a term's work. This is a very different approach either from instructing all the children to replicate a Blue Peter type formula to make identical masks — and woe betide those who get it wrong — or from vaguely asking children to make a mask 'for our assembly' with a few broken eggboxes, a cereal packet and two rubber bands.

Some of the more innovative and purposeful design and technology tasks in classrooms I have visited this year have been in adapting systems of storage, playground facilities, milk distribution etc — or designing 'supermarkets', 'garden centres', or 'cafes' for role play in classrooms. A strong interest in Green Issues has resulted in children tackling topics based on alternative technology or care of the environment. Children have demonstrated high levels of attainment. I wonder sometimes how the secondary sector will be geared to receive and move children on from such levels at Key Stage 2?

□ Evaluating

We found teachers as worried about AT4, Evaluating, as they were about AT1. It was clear that using evaluation as a bolt on process did not work. Children were reluctant to make negative comments about work in which they had invested time and energy. One teacher said, 'We ask the child when they've finished a model or a piece of work, are you pleased with it, or would you like to change it, but they usually say, 'Well, I like it as it is.' 'Moreover, teachers were anxious about giving negative feedback at the end of a task. In our conversations with children we found them fairly down to earth. 'We could have done this bit a lot better, but we can't be bothered.' 'My bird's all cock-eyed!' 'This isn't going to work.' Only once did we find a child inconsolable in an evaluation — because he could not make the wings of his aeroplane model *absolutely* symmetrical!

Two issues emerged. First of all, children have to learn the skills of evaluation. The kind of resourcing of children's thinking we suggested was productive at the imaging and doing stages of the design process can equally apply to learning both example, in the Key Stage 1 SAT to design shelter for pets, the initial exploratory stage would include the evaluation of a range of pet shelters on the market or in do-it-yourself forms. Secondly, evaluation should be built into the processes of designing and doing. In Figure 1 we have deliberately shown the capability features of evaluation right across the other domains. Sensitive teacher intervention can help children to evaluate at the point when they can modify as they work, rather than having to face the prospect of 'doing it all again'. We observed some very productive evaluation discussions set up by the teacher either for pairs, small groups, or the whole class. Sharing insights within a climate of 'critical friends' fed ideas directly back into subsequent phases of children's work.

□ Conclusion

We need much more classroom based research to identify and characterise capability in design and technology, to investigate features of progression and to identify factors which contribute to the development of capability. If we can work towards a better understanding of technology education in primary schools and feed new insights back into the NCC version of Technology, there is rich potential for developing creativity and practical intelligence in children. We have only just begun to see that potential being realised.

□ Bibliography

DES/WO (1989). *Design and Technology for ages 5 to 16,* June, London: HMSO.

Liddament, T. (1991), Design-Talk, *Design and Technology Teaching,* Vol. 23, No. 2, pp.100-110.

NCC (1989). *National Curriculum Council Consultation Report on Technology,* November, York, National Curriculum Council.

NCC (1991) *Issues in Design and Technology,* NCC Inset Resources, York, National Curriculum Council.

Rogoff, B. and Lave, J. (eds.) (1984). *Everyday Cognition.* Cambridge, Cambridge University Press.

Weikart, D. P., Epstein, A. S., Schweinhart, L. and Bond J. T. (1978). *The Ypsilanti Pre-School Curriculum Demonstration Project: Pre-School Years and Longitudinal Results,* Ypsilanti, Mich., High/Scope Educational Research Foundation.

Wragg, E. (1991). Outcasts on the dark side of Pluto, *Times Educational Supplement,* 15.2.91, p.12.