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Technological capability in primary classrooms

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Abstract

This paper is based on analysis of interviews with the staff of twelve primary schools, six in each of two LEAs, and observations of children working in four classrooms - two Year 1 and two Year 3 classes - in the Autumn, Spring and Summer terms of 1990 to 91 - as teachers at Key Stages 1 and 2 implemented the first year of the statutory Technology Order.

Capability in context

When the Technology Order landed on the staffroom tables of primary schools in the Summer of 1990, teachers were already reeling under the strain of implementing the English, Mathematics and Science Orders. For a largely Arts/Humanities educated and female workforce the Technology Order seemed inaccessible and alienating. The language intimidated them. A teacher said:

"We just didn't understand the language of the document. It was on about generating or whatever it was... that sort of thing and the images of generating or something... that was when we really started panicking".

There was also the conceptual difficulty of coming to terms with the innovative model of design and technology embedded in the four attainment targets - Identifying Needs and Opportunities, Generating a Design, Planning and Making, and Evaluating - conceived as domains of an iterative and holistic process leading to design and technology capability. Another teacher admitted:

"I find it very difficult. I've read it two or three times and I can't hold it all in my head. It's so fine and the terms are foreign to me. I keep reading it and going back to it, and it's the fact that you can't dip, which I think you can do with the other documents... that you have to hold on to the whole thing and understand the whole thing."

The teachers to whom we spoke recognised clearly that, despite their efforts at 'self-help' during school based training days, and LEA in-service courses designed to support them, they were lacking in the confidence and the technical and conceptual knowledge and craft skills they needed to implement the order. Interviews we did with teachers in two LEAs reflected the depressingly low figure of one in seven of a national sample of primary teachers surveyed in a Leverhulme Project (Wragg, 1989) who felt competent to teach technology.

They were also anxious about the supervision of children engaged in technological activities and related safety issues. Despite the rhetoric that primary teachers value practical work, research indicates that teachers devote two-thirds of their time to working with children involved in seat-based basic skills activities and little time interacting with children engaged on practical tasks, with the exception of science and maths. (Tizard *et al*, 1988; Alexander *et al*, 1992; DES 1991). In the workshop areas where art, craft, role play, construction play, and technological activities are sited, the most common pattern is for activities to be set up by the teacher at the start of the day, with brief verbal instructions delivered to the whole class about what is expected of them and perhaps reference to the way tools should be handled and what materials might be used. For the rest of the day the activities are sustained by groups of children working independently of the teacher. The teacher makes sporadic visits to the areas - often in a trouble shooting capacity - but rarely observes the processes by which the children work sequentially through the tasks. Occasionally a non teaching assistant or parent will be assigned to monitor the activities, but as Bennett and Kell (1989) reported, these adults are rarely briefed adequately by the teacher as to the purpose of the tasks.

It is not surprising that faced with uncertainties about how to implement the Technology Order, the teachers fell back on their knowledge of teaching and learning in art, craft and design, environmental studies and structured play. A Key Stage 1 teacher said:

"It's more or less what we've been doing all along. We have always done such things as turning the house corner into a shop or something like that, and I think if we carry on doing them we are covering practically everything that is in the document. It's just got a new label, hasn't it? That's basically it".

More defiantly, a primary school head teacher said:

“When this magical thing called Technology was discovered - I don’t know who it was decided to discover it, whether it was Mr. Baker or somebody else - we assessed what technology really included. And basically it’s all the art work, the physical side of the art work - I don’t mean the brain side of it, that probably comes from design somehow. All the baking, all the cooking, the clay work, the box work, the book making, and woodwork - and certainly doesn’t the maths come into technology and technology into maths - and science? It virtually covered everything and as we do a lot of topic based work, technology could be said to be in everything. We just fill in that silly purple form (the DFE curriculum audit form) and really you know technology could be counted up as 100%!”

‘The inertia of past meanings is a formidable barrier to change. In education, you cannot create a vacuum in which to grow a new set of meanings and practices; you cannot stop teaching for a year in order to work in a different way. The show must go on. It is against such pressures that the task of change has to be undertaken’. (Ruddock, 1986).

The distinction that the primary head teacher drew between the ‘physical side of the art work’ and ‘the brain side of it’ is an interesting one, and points to another contextual feature of technological capability in primary schools - the models of the learning process held by teachers and the pedagogical implications of their beliefs for their practice in classrooms. The concept of Design and Technology, defined by the working group as a ‘unitary concept, to be spoken in one breath as it were’ (DES, 1989, 1.6), allows the subject to sit uneasily between the two very different conceptual and pedagogic traditions of the arts and sciences. In primary schools, children’s learning in the visual arts and crafts is rarely systematically supported by direct instruction. Teachers uphold a ‘laissez faire’

These quotations demonstrate the kind of strategies practitioners use in order to cope with change imposed upon them from above. As Jean Ruddock wrote:

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 tasks 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.

tradition, embedded in notions of 'child-centredness', of children being allowed to be creative without adult interference. In science, one of the new order basics for primary teachers, direct instruction and careful supervision of practical work is seen as appropriate. In the two LEAs in which we observed, the strategic model of technology was interpreted very differently. The messages disseminated through in-service courses reflected the value systems of advisers with responsibility for technology employed by LEAs; and such macro-level belief systems had implications for the ways in which technology education was operationalised in schools.

Within classrooms also contextual variables also effected profoundly what the children could do - the support of an informed adult, the children's previous experiences of model making and mechanisms both at home and at school, the availability of appropriate tools and materials, access to information, the patterns of classroom organisation and styles of pedagogy in the schools. However, there were certain features of capability which we identified as critical for the children to make progress in design and technology.

Features of Capability

These features of capability, categorised within three domains - Identifying Needs and Opportunities to Generate a Design, Planning and Making, and Evaluating - broadly relating to the four Attainment Targets of the current (at June 1993) NCC Technology Order (1990), are set out in Figure 1.

Already, as I work with this model, I am finding that I need to refine it, but I want to discuss four features of capability that I find particularly interesting - communicating ideas through drawing, acquiring technical skills, acquiring technical knowledge, and evaluating.

Communicating ideas through drawing

The teachers we interviewed were aware of the possibilities of using drawing as a medium to express thinking, but were uncertain whether children were capable of matching their imaginative abilities with their representational skills. One key stage 1 teacher said :

'I don't think they need to draw and plan at five. I think they want to make it first and possibly record and draw it afterwards. They don't know what it looks like before they've made it. To see it before you've done it, that's hard'.

A key stage 2 teacher said:

"I encourage them to draw their designs before they make a model, but I have to admit that the designs that they make at the beginning, however fantastic they look, very often the end product isn't like that at all. The original drawing bears no relationship to what the children finally produce. I think what actually happens is that they are re-designing as they go along all the time, as they are making things.... I think adults are the same. When they start making things up, often their original ideas are modified drastically, once they get working".

There are two issues to be teased out here - one a cultural phenomenon and the other developmental. There is plenty of research evidence (Hall, 1987; Wells, 1987) to substantiate the claim that the acquisition of literacy skills is dependent on models of literacy behaviour surrounding the child at home and at school. In classrooms children will see reading and writing behaviours accorded high status, but drawing is not habitually demonstrated as a useful tool for organising or representing ideas. More usually, drawing is seen as a servicing agent for the 'real' work of writing stories - 'When you've finished your writing, draw your picture' - or for topic work - 'If you have any time left, copy a picture from the reference books of a Viking ship for the front of your project folder'. Teachers rarely demonstrate drawing skills to young children. In fact, modelling drawing behaviour is often vetoed by the primary school culture of encouraging children to be 'creative' as 'forcing children into an adult mode of representation'. I find this concept hard to equate with the accepted practice of teaching handwriting skills to young children.

A further culturally acquired assumption for young children is that making drawings in primary classrooms is about aiming for a perfect end product. When the researcher asked two six year old boys who had been set the task of designing a hamster exercise area to 'scribble down a few ideas', they looked horrified. We should have recognised that in an infant classroom 'scribbling' is a taboo activity. Yet designers work from note-pad to materials, keyboard to screen, lines to words with an easy flow. Leonardo da Vinci's notebooks provide perfect evidence that thinking in words and lines can be mutually enhancing. Our education system rarely offers examples of adults modelling drawing as a tool for thinking. The two boys set to drawing on a huge piece of paper an elaborate series of disconnected items for a happy hamster - a table and chairs, a bed with pillows and a duvet, packets

of healthy (their word) cereals for breakfast, a Jacuzzi, a pool for it to drink from, and a train set for it to play with. (See Figure 2).

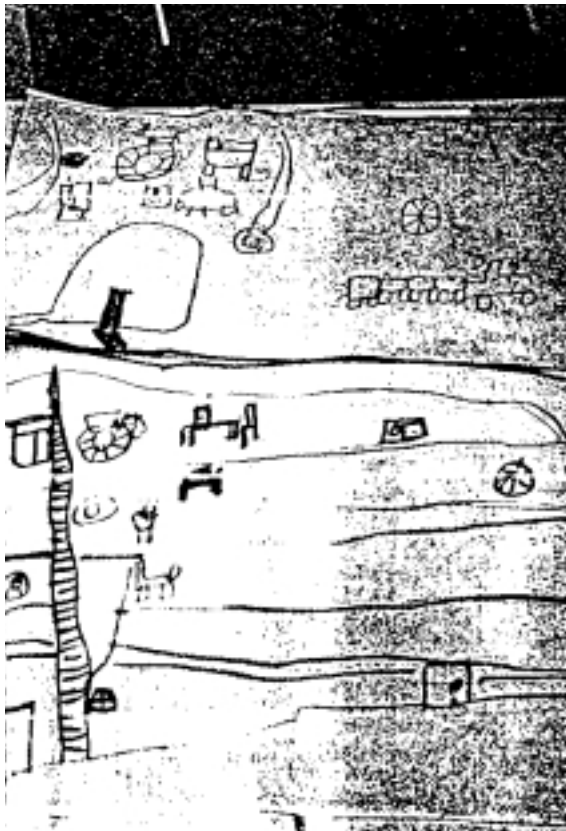


Figure 2

They finally began to draw around these items a cage-like enclosure - horizontal bars representing the sides 'so that he can poke his little head out' and a door 'because he does need to go out for exercise'. When the researcher suggested that they might label some of the design elements - the beginnings of modelling an annotated drawing - she was firmly put in her place. 'We don't want to do that because we're not very good writers'. It became increasingly clear that for these two children the design drawing was actually conceived as a gift for the hamster because they further justified their reluctance to write by, 'Anyway he's only a little baby hamster and he can't write yet...' They were making no links at all between their drawing and its relationship to a 3D model. In fact, towards the end of a long session of colouring their drawing in with felt tips, the dominant child said very firmly to the researcher, with eye contact fixed on his working partner, 'We don't want to make a model, do we?'

With skilful intervention from the children's class teacher the following day, the boys were persuaded to tackle a prototype of the hamster exercise area.

The teacher cued them into the task by asking them to tell her what materials they would need. They listed coloured paper - silver, gold and black (perhaps a concession to their image of a cage); coloured chalks (James had been waiting for the opportunity to get hold of these); a large box, wallpaper, string, pieces of carpet, wood, 'special paper to see through' (for windows?), a hole punch (for air holes), a Stanley knife (for the teacher to cut the window holes). It was clear that the children were beginning at last to image with materials in mind. This brings us to a further dilemma for young children. They are rarely encouraged by teachers to apply their knowledge of materials and their properties to initial design drawings. It is only through direct intervention from the teacher, that the concept of drawing specific parts of a proposed model, defining in 2D exactly what materials are to be used to create the 3D outcome, is developed. No wonder, then, that the children's drawn designs bear so little relationship to their final models. See Figure 3.

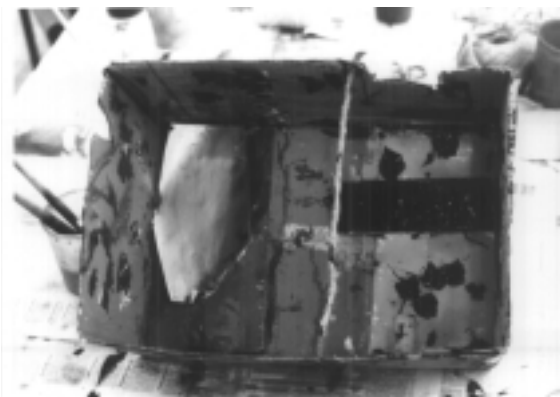


Figure 3

There is a further developmental aspect to be considered. The development of children's competence in drawing has been studied extensively (Kellogg, 1979; Cox, 1991). We know that children struggle to master the graphical conventions of representing scale, spatial orientation and overlap. Expectations of what young children can reasonably be expected to represent in design drawing need to be realistically assessed. Models of different styles of technical drawing need to be introduced at various points along a broadly delineated developmental scale. It may be that the conventions of simple exploded diagrams and annotated drawings should be taught at Key Stage 2 before we expect children to tackle simplified technical drawings at Key Stage 3. There is some evidence that young children can cope with recording their model making in drawings after they have worked with materials. Figure 4

shows the drawing of a five year old child who was asked to record his lego model - a staircase - in drawings, so that other children could try to replicate it. His second, much improved version is shown in figure 5.

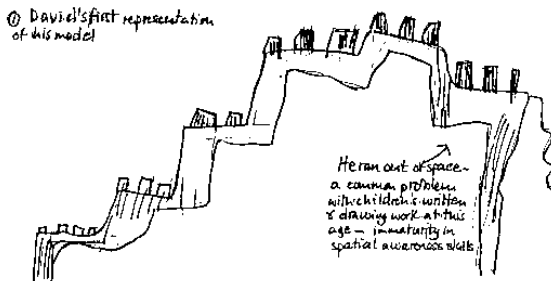


Figure 4

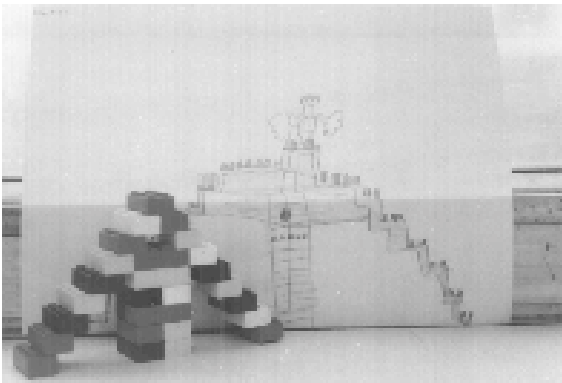


Figure 5

This way round, at least the drawings are grounded in understanding of the characteristics of the materials used. Research by Banta (1980) suggests that it is at about nine years that children engaged in construction play tasks with building blocks can represent their design intentions in drawn form accurately. But there is little empirical evidence to help teachers to structure a curriculum in this aspect of capability.

Acquiring technical skills

The second and third features to be discussed are within the second domain of capability - Planning and Making. Our observations of children handling tools and equipment confirmed that primary teachers' concerns about their ability to model appropriate skills in cutting and joining hard materials and safety aspects of using cutting and drilling devices were well founded. As one teacher said to us:

'It's not only inflicting injuries on themselves or other people, but the furniture, tables and chairs and the floor you know. You might find yourself ending up with a pile of firewood!'

We identified two common dilemmas. The first one is a pedagogical concern. We observed little direct instruction or demonstration in the handling of tools and equipment. One primary teacher was clear about the need to give direct instruction:

'There's a school of thought that sort of says to the kid 'You've got to find out'. But it's very frustrating for a child thinking how the hell do I join these two pieces of wood together without it falling apart when I want to make something by not interacting with them and saying 'Look, this is how you do it. This is how you use a saw and this particular tool you are using is for this particular function'. Because that's how people use tools. They don't use a great big saw when they need to use a small one. There's got to be some formal input in some ways - how we use tools, how we use materials, what materials are good with other materials - that type of thing'.

The second concern is developmental. We observed children handling brand new and expensive tools - displayed proudly in workshop areas - with great difficulty. Saws and hand-drills caused particular concern. Children were struggling to master the gripping, positioning and moving of hands on a range of types of tools - some with pistol grips, some with indented handles, some large, some small, some rigid, some flexible. We also saw simple tools like scissors and brushes being incorrectly handled and left handers being left to struggle with equipment designed for right handers. What seems lacking is research evidence about the development of children's fine motor control and hand/eye co-ordination and the application of that knowledge to the design of school equipment. What is also lacking is the study of the physical development of young children in initial and in-service training programmes. It has been lost in the shift away from Child Development courses in initial primary training towards curriculum and policy concerns. Teachers seem to be unaware of the significance of the development of physical skills and its relationship to the levels of demand of practical tasks. They do not have sufficient knowledge to match tasks to likely levels of competence or to teach skills to ensure systematic progression in fine and gross motor control.

Acquiring technical knowledge

We observed children drawing on technical knowledge acquired from previous experiences. In a small village school children were making model diggers in a rural setting where large agricultural machinery was part of their daily lives. They had clearly absorbed a lot of information about leverage and joints. The teacher had also resourced the children's modelling through a class discussion, a set of picture books with diagrams and photographs of machines, and was planning a visit to a building site. The quality of the children's problem-solving strategies bore witness to the quality of teaching and preparation that preceded the task. Without a grounding in conceptual understanding, the children would not have been so competent in constructing their mechanisms.

In an inner city school we observed three girls achieving the satisfaction of completing a representation of a traction engine working from a sequence of diagrammatic instructions. The model was aesthetically pleasing in its final version but they did not learn how to make a working model as specified in the instructions they were following. It is significant that a small group of boys, inspired by the girls' model, set out to make their version of a traction engine and were far more interested in the working components. They brought to the task knowledge from working with Lego and Meccano vehicles and from observing fathers, brothers and uncles making models. We found that girls were not often pushed to acquire technical knowledge, and because the role model was absent from their lives outside school, they were content to stay at a basic level of competence and confidence in mechanical engineering.

Evaluating

The teachers with whom we worked found the prospect of getting children to evaluate their work daunting. As one teacher pointed out:

'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!'

However sensitively asked, the teacher's questions, because of the in-built imbalance in the power relationship between teacher and taught, seemed to imply criticism. Children naturally reacted defensively to this. Worse still, if the child admitted that a piece of work might be improved, the teacher might ask them to do it again! Evaluation as a bolt on process simply did not work. Many children were genuinely puzzled at the idea of having to

'improve' something on which they had worked hard. I suspect they simply did not have a range of mental models of alternatives against which to make informed judgements. Teachers struggling to get children to redraft writing have exactly the same problem. Finally, children lacked the vocabulary to evaluate effectively. 'I like it because it's nice', or 'I like it because it's red' were the kind of responses young children made.

Far more productive, the teachers discovered, was for evaluation to permeate the whole iterative cycle of designing and making. It was particularly productive to pair children to talk to each other about the changes they might make in their products. The decisions were fed back at whole class or group discussion times. In this way the knowledge, vocabulary and attitudes to improve evaluation skills were built up over a long period of time. A comment from an experienced teacher of technology summed this up:

'I find mine unwilling to change, modify designs. Even if something was falling apart, they'd be happy with it. But it all depends on how you treat them, because the next time they would do it differently. At a later date what has gone wrong has penetrated and they do realise and do it differently next time. But I don't think it's fair to ask them at that age to re-do it. I think you can put them off'.

It would be interesting to look across curriculum areas to investigate whether this reluctance to make changes has a generic and developmental stage in, for example, writing, drawing, and model making.

Conclusion

There are so many features of design and technology capability that are under-researched. These four specific features will be investigated further during a second phase of research due to start in January 1993.

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