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A study of aspects of design and technology capability at key stage 1 and 2

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Abstract
It is difficult for the busy primary teacher to monitor everything which is going on in a situation where learning is happening in many different ways and much of the design process which children work through goes unnoticed. Closer observation of children designing and making reveals their emerging Design Capability in many forms.

This paper reviews research done by the author into aspects of Design and Technology capability in primary age children, specifically: the use of drawing when formulating design ideas handling tools and equipment, and how children approach evaluation.

The nature of capability
When does a child become 'D&T Capable'? At level 10? Capability is, arguably, a relative term. A child operating at level three is more 'capable' than one who is still working towards level two. Yet the five year old who can establish criteria for the evaluation of his efforts is more capable than the fourteen year old who cannot yet do this. Capability is organic, it grows with the child.

Initial research by Angela Anning and Gill Kicks, at Leeds University in 1991 looked into how D&T had been implemented at KS1 in the early years of the Statutory Order. It revealed several issues which needed further investigation. Three such areas are the focus of this paper. They are:
- drawing evaluation
- motor skills

Research carried out by the author in 1993 in four primary schools in two very different Local Education Authorities serves as the basis for this further work. The classes ranged from year two to year six. The year two children were undergoing their non-mandatory SATs at the time.

Drawing
More often than not children are asked to "draw me one then make it." They do not see this as an essential vehicle for channelling thoughts, more a hindrance to the 'real' task of making. Using drawing to convey what is going on in your head is a skill which needs to be taught and a habit which needs to be carefully fostered if is not to become a chore.

Drawing styles tended to fall into five broad categories, which of course are not mutually exclusive. Some of these styles came more naturally to children than others.

Sketching. It is difficult to persuade children to sketch rough ideas - they prefer to do presentable drawings of the finished product. In the project schools sketching in particular was something which very few children tended to do naturally. It was associated with careless work and seemed to be resisted in favour of 'neat' work. Even when the children were asked specifically to sketch, and taught techniques for doing so, not many children took readily to the idea when they were next designing.

Annotated drawings. Children were often seen to annotate their drawings, but the information they included was not always relevant.

Exploded diagrams. This technique was unfamiliar to a lot of the children but they soon took readily to the concept and considered it rather fun. Children were asked to 'explode' a can opener and draw it. This helped them to look in close detail at an artefact and record things which would otherwise have gone unnoticed.

Finished drawings. The 'pretty picture syndrome'. The notion of working drawings is difficult to get over - children are so used to producing pictures as a final outcome it seems wrong, if not futile, to draw something before making it. Consequently, many designs end up as 'finished products' in themselves.

Drawing in 2D and 3D. Children in the participating schools were observed to attempt three dimensional representation when drawing from direct observation as early as year two, but most of the children had not yet mastered the technique until much later. One year four child, William, when drawing an exploded diagram of a can opener, drew everything in 2D apart from the turning handle. This he very carefully made to look three dimensional by drawing the visible side edge:
He was aware of what he was trying to do and said that he had been taught how to do it by his older sister. This is clearly an example of a taught technique which William is applying in a different context.

When drawing design ideas as opposed to drawing from observation there is less of a tendency to use 3D unless prompted.

Children need to understand the purpose of their drawing - that is to say to produce a working drawing and not a final outcome. Given this criterion, it follows that the drawing needs to convey sufficient information to tell the observer all there is to know about the proposed design. It needs to be a simple line drawing, probably annotated, and almost certainly containing different views and smaller details. But is this what young children produce? The answer is of course very rarely. Children at this stage use some of the devices some of the time, and only if they have been given the skill to do it beforehand.

One of the biggest problems is getting children to think through, in quite an abstract way, what they think their final outcome is going to look like. For example, some year two children were designing pencil cases. Kirsty’s design was for a pencil case in the shape of a clock:

It was to be hinged at the bottom and it needed a fastening at the top. Kirsty drew the clock face and coloured it in neatly. When she explained how the pencil case would work, she said:

“You open it up like this and the pencils go in there and then you fasten it at the top.”

Teacher: How will the two sides be joined together at the bottom, Kirsty?
Kirsty: Sellotape.
Teacher: And what about here at the top, how are you going to fasten it?
Kirsty: I’ll put a flap thing on it.
Teacher: Could you draw me the flap to show how it will work?
Kirsty drew a line to represent the flap.
Teacher: How will the flap work Kirsty?
Kirsty: It will go over there. (She points vaguely at her drawing.)
Teacher: What will you need to make the flap?
Kirsty: I don’t know.

Kirsty had no idea what she would do for the fastening at the top of her pencil case. She obliged her teacher by drawing a ‘token’ fastening, but she was unable to think in detail about how it would work. This begs the question as to whether we should be using drawing to formalise design ideas with young children or whether instead we should be talking through the design, probably with the materials as a concrete reference point.

The children observed on the study hardly ever referred to their drawings once making had begun. Even the older children only made token referrals, usually at the prompt of a teacher.

Finished products quite often do not resemble the original drawn intention. This is due to many factors - resource limitations probably being the overriding one. There is also a tendency to draw/plan far too sophisticated a design which is beyond the practical capabilities of the child. Again, the older children could use their initial designs as a reference point when evaluating their final outcome more easily than the younger ones because, on the whole, they contained more relevant information on which to base criteria for ‘success.’

**Evaluation**

In the course of designing and making activities children can evaluate -

- their own work
- the work of peers
- the work of other designers in the form of existing artefacts

Children evaluating their own work...

Evaluating their own work is a natural, but not always obvious part of any child’s activity, but it is not necessarily articulated unless prompted by a teacher or peer. In designing and making teachers are encouraged to get children to evaluate their work as an ongoing process, though many teachers still perceive AT4 in the current order to be ‘the thing you do at the end of a project.’ This is not helped by the linear way in which the ATs are presently numbered.

When evaluating their own work, children in the junior classes were quite willing to talk about the problems they had experienced and the ways they had modified their design as they went along. The younger children, on the whole, seemed far more satisfied with their work and could not recall as many problems along the way. Take for example these year two children who are talking about the protective headgear they have made for their HatSat...

**Teacher:** What are you doing here, Salim?
**Salim:** I’m sticking the peak onto my hat.
**Teacher:** Why do you need a peak on your cap?
**Salim:** To keep the sun off my face!

(teacher and student both look at the clear plastic peak of the protective headgear)

**Teacher:** Will your peak do that? Will it keep the sun off your face?
**Salim:** (The peak is extremely small and made from a clear...**
Salim: Yes.
Teacher: Do you think you could do anything to your peak to make it keep the sun off your face a bit more?
Salim: No.

The key stage one children in the study did not tend automatically to establish their own criteria for evaluating their work. During the HatSats of 1992/1993, children were asked how successful they thought their hats were at protecting their heads from whatever it was that they were supposed to be protected from - sun, rain, falling rocks etc. In many cases it was obvious that the hats afforded no protection at all - perhaps they had used non-waterproof material for a rain hat or clear plastic for a sun hat. They could see when prompted that the hats did not fulfil the original criteria, but rarely volunteered this as a criticism of their own efforts.

Older children were more critical of their own work. They expected more realism and became frustrated when the right materials were not available. Modifying their design ideas to take into account the restrictions of the classroom became a frequent event and one which was seen as inevitable on the whole.

Children evaluating the work of other children...
When asked to evaluate the work of their peers, children of all ages were fair and constructive in their opinions. The less able children had some difficulty in considering what they would have done in the other person's position. The majority of children were able to offer sensible suggestions as to potential modifications and these were, usually, readily accepted by the child whose work was under scrutiny! It was evident which groups of children had been in this kind of critical role before and those who had not had experience of sharing their work with others.

At what age, though, are children capable of making critical evaluations of the work of their peers?
Take for example this year two boy who is discussing with his friend and his teacher the hats they have made for their Technology assessment task:

Teacher: Richard, what do you think of David's hat?
Richard: Yes but the sun would get through this bit here. {points to a hole where the sellotape has failed to join the rim and the top successfully.}
Teacher: Do you think David could have done anything differently, Richard?
Richard: Yes he could of used a better bit here {peak } because it keeps bending. And I don't like that material. I didn't use that on mine.
Teacher: : Is there anything you like about David's hat?
Richard: He's put a Thunderbirds on the front. I like that.
Teacher: Is is a good hat Richard?
Richard: I suppose so. I'd give it, erm, 5 out of 10! Teacher: And what would you give your own hat?
Richard: 10 out of 10!
Richard was not very complimentary about David's work, but his comments were not malicious - merely honest. At the end of the day, Richard said what was required about his friend's efforts, but, as is common with young children, he was unable to accept that it was any better than his own, to which he awarded a much higher mark out of ten!

Children evaluating existing artefacts - using AT4 as a starting point...
"Well, it looks good but it’s not that good because you can’t put rubbers and things in it, you can only put pencils in it. The other one is better because it's got loads of space and you can put lots of things in it. When you go to older schools sometimes you do writing with pen, you wouldn’t be able to put a pen in there... "
Stephen, age 7, comparing two desk tidies.

Evaluating an existing artefact is often an excellent starting point for discussion, especially, although not exclusively, with the youngest children. By asking them to talk about familiar objects and say why they like them, what is good about them and what could be made better, children are beginning to think critically about their environment and learn that it is permissible to have a viewpoint which may differ from that of others (including the teacher) and that their opinion is a valued contribution to the discussion.

The artefacts which children were asked to evaluate during the study were commonly found pencil cases and desk tidies.

The aim was to get the children to evaluate the desk tidies in general terms with as little prompting as possible. However, the questions were designed to get them to think about the following issues:
• their personal preferences, and the reasons for their choices,
• whether the desk tidies were 'good' or 'bad'
• the age group they were aimed at.
• the value for money.
• the materials they were manufactured from.
The children tended to refer to the physical appearance of the items, describing them well but, surprisingly, making little reference to colour or size. There were many comments about what could be stored in the desk tidies and what the children would use them for. Very few comments were made about what the items were made from. When asked specifically, the children all knew the materials used in the manufacture. Many comments were made about what could be done with the desk tidies. The items were familiar to the children and they could relate well to how they would be used if they owned them.

On the whole the children were very fair over their comments and were willing to make negative as well as positive comments about the items. However, if an object happened to be a child's favourite or least liked colour, or contained a logo which was particularly important, then this influenced the younger children quite a lot.

The children seemed very able to consider how other people might use the desk tidies especially peers, friends and siblings.

**Gender stereotypes**

Stereotypical comments about gender and associated colours are ingrained from an early age! “This is a girl’s - it’s pink!” “I think this is made of boys’ colours.”

This was also apparent with comments about style and appearance - there were definite boys’ and girls’ styles as well as those which would appeal to both. Funnily enough, these seemed to differ from group to group! It was very clear that each group developed its own set of dynamics which influenced the way the discussions went. This begs the question: how much are individuals influenced by group pressures?

Children at the top end of key stage two seemed to be very aware of what it is ‘politically correct’ to say - they knew that colours shouldn’t be associated with gender, but when it came to the crunch they were not prepared to stick by what they said. Take these two extracts as an example. In the first conversation, these year 6 children are being very non-sexist in their attitudes to a cute furry pencil case which looks like a panda:

Teacher: Who do you think this one is meant for?
Rachel: It could be for anyone really.
Donna: I think it’s for younger children, girls and boys.
Teacher: Girls and boys? Isn’t it just for girls?
All: No.

Then, later on, the children are discussing a pencil case which is mostly pink in colour and has a picture of Barbie on it:

Chris: I think this one’s meant for a girl.
Teacher: Why is that Chris?
Chris: Well, it’s got a picture of Barbie on it, and it’s pink, so I don’t think boys would buy it.
Teacher: Don’t you think boys would go for this one then?
Chris: No. I would if it was another colour...
Kayleigh: It’s a girl’s thing because it’s pink.
Teacher: What if it had the same things in it but it was another colour? Yellow, or red or something. Would that make any difference?
Kayleigh: That would be for boys.

Children can be quite impartial over their opinions or they can show bias for seemingly trivial reasons. A few children said that a given desk tidy or pencil case was the best for the job because, say, it was their favourite colour or because they liked it. More children, however, chose the ‘best’ one on the grounds of practicality - it was the biggest, or made from strong material.

**Motor skills and tool handling in D&T**

Very few children at key stage two are allowed access to power tools unless they are in a middle school where they may well work in a specialist workshop and hence have access to disc sanders, pillar drills and so on. Children at key stage one, and most children at key stage two, are restricted to hand tools. The only power tool seen in use was the ‘Shapersaw’ - a motorised fretsaw which operates on the principle of vibration and which is completely safe to use.

Children have been seen to use small hand tools such as scissors and junior hacksaws quite competently from a very early age. Children in different educational set ups, however, are subject to varying perceptions of what they should be allowed to do. For example, a pupil of, say, nine or ten in a middle school will have access to specialist equipment and a specialist teacher, whereas the same age child in a primary school may not. The teacher in the middle school will expect far more of the child in terms of independent activity and use of resistant materials and ‘hazardous’ tools than the primary teacher might. The use of hot glue guns is a typical example of this attitude. The consequence is that children in the specialist environment will have the potential to produce far more sophisticated...
outcomes than the child in the primary classroom, and will develop a wider range of skills and techniques at an earlier age. This has implications for standardised assessment across the country.

There has in the past been a reluctance in some schools to teach skills, be they tool handling or techniques such as cutting and joining. Skills teaching is erratic, and not always correctly done. Quite often the teacher is not confident or has not received adequate training in tool handling and therefore is not aware of the correct procedure.

Tools likely to be encountered during designing and making, and the actions required to use them at primary level, might include those listed below:

- **SHAPING**
  - coping saw
  - file
  - shaper
  - saw

- **JOINING**
  - screwdriver
  - hammer
  - glue gun
  - bradawl
  - glue spreader

- **DRILLING**
  - hand drill

- **HITTING**
  - hammer

- **CUTTING**
  - scissors
  - craft knife
  - hacksaw

- **MARKING**
  - ruler
  - pencil
  - compasses
  - tenon saw
  - sand block

In order to use these tools the child must develop the ability to hold and manipulate them in a safe and effective manner. There is a need to grip, twist, rotate, squeeze or whatever according to the function of the tool, all of which require fine movements of the hand and fingers in co-ordination with the messages received from the eyes. This seems quite a tall order, when you think about it. The point is, perhaps, that we don’t think about it - all these actions come ‘naturally’ to us.

There does not seem to be much on the hand tools market which is designed for small hands. Children as young as nursery age were observed grappling with enormous tenon saws - but this was an exceptional mismatch and on the whole teachers were trying to provide appropriately sized tools for the children in their classes. However, quite often we see young children coping with over-sized saws, knives which are ‘safely’ blunt and hammers which are too heavy. Even older children have difficulty with 6oz. hammers, large surforms and such like.

This has implications not only for the safe use of the tools, but also for the degree of accuracy and fineness of movement which can be achieved. There seems to be a degree of nervousness about giving children sharp implements, lest they injure themselves. It is probably more likely that a child would be injured trying to cut with a ‘blunt knife than a sharp one. Children are quite good at self preservation!

There does, however, seem to be a paucity of child sized tools on the market. In order to equip children with a small saw, for example, they are often given a hacksaw to cut through almost everything.

**Summary and Conclusions...**

This study attempted to look at three aspects of designing and making in primary age children - drawing, evaluation and tool handling.

With a short time span and three areas to cover, there are inevitably more questions than answers and much more research needs to be done in the way children become design and technologically ‘capable.’

The umbrella question which all teachers need to have answered is ‘Can they actually do what the Statutory Order requires them to do?’ Given that the Statutory Order for Design and Technology keeps changing, this is a difficult one to answer definitively. However, the underlying process of designing and making remains the same, and it is this which determines D&T capability.

I would suggest that there are one or two difficulties which have become apparent on this study:

Firstly, the requirement to plan ahead and commit their ideas to paper is difficult for key stage one children. They cannot anticipate exactly what their outcome will look like {can any adult?} and they need to work with the materials in order to discover what can be achieved. Although there is nothing in the Order which states that children need to approach the ATs in a linear fashion - heaven forbid - it is implicit that ideas are first of all ‘generated’ and then acted upon. I would like to reassure KS1 teachers that this articulation of ideas need not necessarily be on paper...

Children can and do use a variety of drawing devices in order to convey their ideas. Techniques need to be taught and children encouraged to apply what they know in a design context. Children who were familiar with techniques such as annotation, plan drawing, details, sketching and so on produced far clearer initial designs when they chose to use them.

Secondly - the role of evaluation is often hazily perceived by teachers, still quite often being the ‘thing you do at the end.’ Teachers need to foster evaluation as a skill by giving pupils practice in making judgements not only about their own efforts but also the work of other children and by evaluating existing products. The emphasis on this in the latest Technology proposals is to be welcomed.
The value systems which underpin the way children approach evaluation is the subject of further research by the author.

Thirdly - the motor skills required to use hand tools are generally acquired in other contexts long before the child ever comes to design and make. The problem arises with the provision of inappropriate tools which are too heavy, too blunt, too big, having the wrong type of saw blade or not robust enough.

This paper only scratches the surface of these three areas of D&T activity, and much more study needs to be done if we are to fully understand the way in which primary age children, and their teachers, acquire the elusive notion of Design and Technology Capability.

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