8. Creativity Through Design and Technology

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Introduction

In 1999 the government in England invited Professor Kenneth Robinson of Warwick University to chair a working party concerned with creativity in education. Two government departments were involved in commissioning this work – the Department for Education and Employment and the Department for Culture Media and Sport. The members of the working party consisted of musicians, artists, scientists, entertainers, entrepreneurs and writers but curiously no designers or technologists. The report '*All Our Futures: Creativity, Culture and Education*' (Robinson, 1999) argues that a national strategy for creative and cultural education is essential to unlock the potential of every young person. It saw creativity in terms of the task in hand as having four features:

- using imagination
- pursuing purposes
- being original
- being of value

In this review talk, I will concentrate on being creative through designing and making useful artefacts. It is of course possible for other 'subjects' in the school curriculum to teach pupils to respond to tasks that engage with these four features – writing an essay or poem in English, composing a tune or song in music, painting a picture or making a sculpture in art, developing an

explanation in science. I consider designing and making a unique sphere of creative activity in which pupils 'intervene in the made world' (Department for Education and Science & The Welsh Office, 1988). There is no doubt that literature, the visual arts and music provide stimulus for the mind and the senses which make living in the world more pleasurable and profound. But they do not intervene in the made world in the same way as design & technology. Whereas science requires creativity to reveal and explain what is, design and technology is concerned with what might be and utilises the creativity in designing and making to bring into existence items of use hitherto unknown. Gunter Rhopol captures this well writing about engineering "*He (the engineer) has to conceive of a concrete object which does not yet exist, and he has to determine spatial and temporal details which cannot yet be observed, but will have to be created by the designing and manufacturing process*" (Rhopol, 1997, p.69). An essential feature of these items is that they are functional across a wide spectrum of functionalities – working technically, appealing aesthetically, meeting economic constraints, avoiding harm to the environment, being socially acceptable and responding to users' needs. It is through the act of designing that this wide range of requirements is met.

In thinking about designing by pupils in schools, the Electronics in School project developed a description of the design decisions that pupils may be required to make (Barlex, 2007a). It can be shown diagrammatically in Figure 1. The five key areas of design decision are: conceptual (overall purpose of the design, the sort of product that it will be), technical (how the design will work), aesthetic (what the design will look like), constructional (how the design will be put together) and marketing (who the design is for, where it will be used, how it will be sold). The interdependence of these areas is an important feature of design decisions; hence the lines connect each vertex of the pentagon to all the other vertices. A change of decision within one area will affect some if not all of design decisions that are made within the others. Usually the teacher identifies the sort of product the pupils will be designing and making. This makes it very difficult for pupils to engage in conceptual design particularly if they are required to make what they have designed. But even if the type of product is identified for the pupils there are still many opportunities for making design decisions in the other areas.

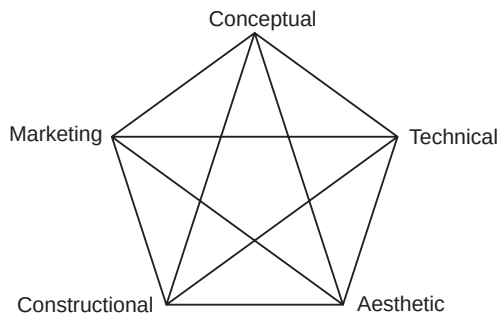

Figure 1: **The design decision pentagon.**

A Pupil's Designing and Making Journey 5 – 13

Here follows a not untypical designing and making journey that could be carried out by a pupil at school as he or she grows from being a child aged 5 to a young person aged 13 years. It describes the creativity embedded in this designing and making by considering the design decisions the pupil has made in terms of the design decision framework noted above. Quite deliberately this will not consider artefacts involving food or textiles, as although the successful use of these materials features in design & technology in England, this is not the case in most other countries. Hence it is not a 'complete' journey as might be experienced in England. It features just one example per year whereas in reality pupils will tackle several tasks per year. However, it does reveal a) the creativity that can be achieved through designing and making and b) the way the demands of designing can be increased as pupils become older. The items considered will come from the work of the Nuffield Design and Technology Projects and the Design & Technology Association's Modernizing the Curriculum Initiative. The sequence of designing and making tasks and the associated design decisions is summarized in Tables 1 and 2. Inspection of the tables reveals the following.

The nature of the artefacts designed becomes more complex as the pupils become older. This is a deliberate ploy on the part of the curriculum developers to meet the requirement for pupils to make progress. This increasing complexity derives in part from the changing technical functions of the artefacts to be designed, which in turn increases the range of constructional skills that the pupils need to deploy to make the artefact. The constructional skills are also deployed to some extent in meeting the aesthetic requirements of the artefact and these have to be resolved by considering who the artefact will need to appeal to and their likely tastes. Pupils meet these ever increasing technical, constructional, aesthetic and user requirements of the tasks through the way they make design decisions.

Table 1: **Task sequence summarizing tasks and design decision for pupils aged 5 – 11 years.**

From the Nuffield Primary Design and Technology Project		
Year	**Task**	**Design Decisions**
Year 1	Which parts of your picture should move? Design and make a moving picture that tells a nursery rhyme or a simple story using paper, card, found pictures, found materials and paper fasteners	What the picture will be about What images the picture will contain How the images will be arranged Which parts of the picture will move The movement of the moving part of the picture The mechanisms to use for the movements Additional features to improve the picture

Year 2	How will your roly poly move? Design and make a simple push-along toy (a roly poly) using a mixture of found materials, paper and card. The toy should provide amusement in both its appearance and the ways it moves. It may be for the children themselves or for other younger children.	The sort of movement required How to achieve this movement How to attach the body to wheels The overall proportions The appearance of the body The appearance of the wheels
Year 3	What music would you like to make? Design and make a simple musical instrument and use it to play a part in a piece for four players.	How the music maker will work What the music maker will look like How the music maker will be constructed What the music maker will play
Year 4	How could a carrier make the job easier? Design and make a carrier that meets the needs of a person (who may be the child) who has to carry particular items.	Who the carrier is for What the carrier will carry How the carrier will be constructed How the carrier will work How the carrier will be decorated
Year 5	How fast should your buggy be? Design and make a controllable, battery-powered toy vehicle using card, wood, found materials and a variety of mechanical and electrical components.	Who the toy is for How the toy will be constructed The functions The appearance
Year 6	Should your creature be fierce or friendly? Working in groups to design and make a statue of a creature that will welcome visitors to the classroom during the day or act as a guardian "after school" and deter intruders.	The appearance of the classroom creature The nature of the individual parts How parts fit together to form a stable structure The construction methods
All the above tasks available at www.primarydandt.org		

Table 2: **Task sequence summarizing tasks and design decision for pupils aged 11 – 13 years.**

From the Nuffield Secondary Design and Technology Project		
Year	**Task**	**Design Decisions**
Year 7	Masks To design and make a face mask incorporating simple electric or electronic effects. Design and make an illuminated mask suitable for use in a school play in which there are scenes of darkness	The customer The performance of the product The appearance of the product The way the product works The way the product fits together The materials, adhesives, fixings and components

Year 8	Electronic Opportunities To design and construct an electronic sensing system to meet an identified need. Design and make a sensing device that will activate an alarm when the temperature in an animal's hutch drops below a set level.	The point of sale The customer The performance of the product The appearance of the product The way the product works The way the product fits together The materials, components, adhesives, fixings and finishes
All the above tasks available at www.secondarydandt.org		

Classroom Conditions for Creativity

The Nuffield Design and Technology Project and a government agency, QCA (the Qualifications and Curriculum Authority) responded to the Robinson Report by inviting 20 teachers to attend a full-day meeting at which they presented pupil's work in art and design and design and technology that they considered creative. This was followed by visits to a selection of schools to watch lessons in progress and a further full-day meeting in which teachers presented and discussed pupil's work. From this overview it was possible to identify four features that had to be in place for pupils to act creatively in either subject.

- The activity had to be presented in a context to which the pupils could relate.
- The activity had to be supported by a significant stimulus which was often, but not exclusively, intensely visual.
- Focused teaching was necessary to provide knowledge, understanding and skills.
- An attitude of continuous reflection needed to be encouraged.

But the observations of lessons and the resulting work revealed that these four features alone do not ensure creative activity. The deciding factor is the way they are managed. This must be done so that pupils can *handle uncertainty in exploring and developing outcomes*. There must be some risk associated with the endeavour in terms of the "originality" of the activity as far as the individual pupil is concerned. This can be shown visually as in Figure 2 using AND gate notation to indicate the range of requirements. As a means of disseminating the findings of the Nuffield Curriculum Centre and QCA research, the Nuffield Design and Technology Project held a joint invitation seminar with DATA (the Design and Technology Association) with the provocative title *Creativity in crisis? Design and Technology at KS3 and KS4*. Presentations were made by researchers, education authority advisers, and teachers followed by a series of working groups. The resulting paper (Barlex, 2003) became Research Paper 18 from the Design and Technology Association. It provides a snap shot of concerns about creativity in design and technology at the beginning of the 21st century. One of the contributors to the seminar was Patricia Murphy and in her presentation (Murphy in Barlex, 2003) she discussed two broad categories of teacher 'voice'.

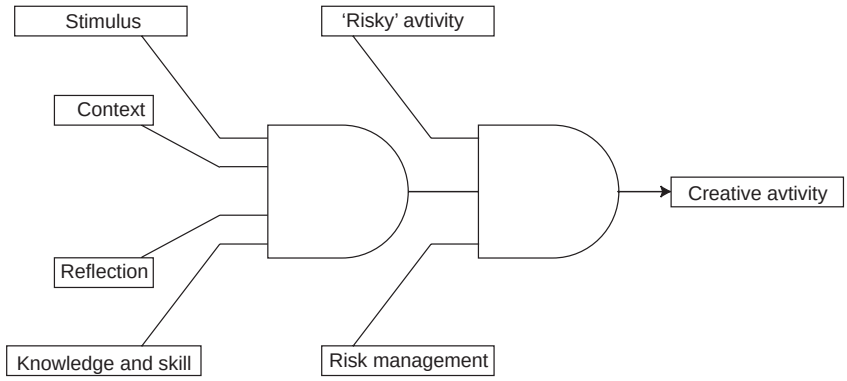

Figure 2: **The double AND gate model for teaching for creativity.**

First, there is the voice that aligned itself with a hegemonic pedagogy:

- Learners are passive receivers of information
- They are not motivated to learn
- Can only learn if knowledge was presented 'pre-digested' by the teacher
- The teacher has sole authority for the curriculum and learning outcomes
- The teacher has to provide tasks which are based on instructions and are school focused
- Any problems with learning, rests with the learner, not the teacher i.e. a deficit view of pupils limited by their innate abilities

Second, there is the voice that was strongly aligned to the situated view of learning:

- Intellectual abilities are socially and culturally developed
- Tasks need to be culturally authentic
- Prior knowledge and cultural perspectives shape new learning
- Learners construct rather than receive meaning
- Pupils share responsibility for learning with teachers
- Pupils are motivated by dilemmas to which they are emotionally committed

Those teachers with the first voice hold a pedagogy that is inimical to supporting pupil creativity whereas those with the second voice are able to be highly effective in supporting pupil creativity.

Creativity through Designing without Making

Insisting that pupils should always make what they have designed can undermine pupils' autonomy especially if they have limited making skills. The Young Foresight project deliberately avoided this

difficulty by requiring pupils to work collaboratively in designing but *not* making products and services for the future, utilising new technologies as a starting point (Barlex, 2007b). The focus of the Young Foresight project was to enhance pupil creativity through improving pupil designing skills. The activity of designing without making was not intended to supplant designing and making or making as activities that may be used to enhance creativity but as a complimentary activity to such other learning approaches. The project developed a framework that pupils could use to generate and justify ideas for new products. Pupil are asked to consider four features (i) technology (the means by which the product works), (ii) people (the extent to which the product meets needs and wants), (iii) society (the extent to which the product will be acceptable to society) and (iv) market (the means by which people will be able to access the product).

Some of the products and services devised by groups of 14 year old pupils in response to the challenge of utilising the stress sensitive conductor QTC (Quantum Tunnelling Composite) include the following:

- Clothing that changes colour as you dance
- Car tyres that sense their internal pressure
- An epileptic fit detector
- A self-weighing suitcase
- An arthritis treatment device
- Keep fit apparatus
- Depth sensitive submersible
- Internal heart beat monitor

These ideas show the use of imagination, the pursuit of purpose, originality and value – the four features of creativity identified by the Robinson Report (1999). If the pupils had been required to make what they were designing, it is extremely unlikely that they would have shown this level of creativity. Indeed, designing without making, gives pupils the opportunity for conceptual design.

Recent Developments from the Design and Technology Association

The Design and Technology Association's Digital Design and Technology initiative has developed a starting point approach to engage pupils with the designing and making of electronic products. The starting points were chosen on the grounds that they could lead to pupils designing and making electronic products of varying complexity depending on the sophistication with which the pupils responded. Hence the starting points are not age or key stage specific. The six starting points identified were: playtime, keeping in touch, keeping secure, staying safe, thinking machines and other worlds. There are of course many other possible and valid starting points but for the purposes of this exercise this number was felt to be sufficient and provided across the set, a sufficient variety to be of interest and use to both teachers and pupils. On the Project website (www.ectcurriculum.org) the starting points are presented as visual brainstorms allowing the teacher and the class to

explore the context for a wide range of possible briefs. This very open approach allows teachers and pupils to develop briefs which they consider are worthwhile i.e. they have control over the fitness of purpose of the products they choose to design and make. This sharing of task definition between the teacher and the pupils is strongly aligned to the situated view of learning (Murphy, in Barlex, 2003) that is highly supportive of pupil creativity. In an extension of the open starting point idea, the one design and technology teacher (P. Holton, personal communication, 2010) has used the definition of technology cited by Arthur (2009, p. 50 – 51).

> *"A technology is a phenomenon captured and put to use... the phenomenon is harnessed, seized, secured, used, employed, taken advantage of, or exploited for some purpose"*

It is an unusual approach within design and technology education to ask pupils to consider a phenomenon and develop from it, through designing and making products that utilise that phenomena. In this task pupils are introduced to the phenomenon of the Peltier effect enshrined in a solid state device that when activated transfers heat from one side of the device to the other side against the temperature gradient. Pupils have found the "cold on one side hot on the other side" sensation highly intriguing and in response to this intrigue the pupils will be tasked with investigating how to maximise the effect for cooling purposes and once they have an understanding of this design and make a variety of cooling devices for different purposes that they consider worthwhile – everything from a drink cooler to maintaining an organ for transplant at the correct temperature. This task is particularly unusual in that it confronts pupils with the nature of technology (a phenomenon captured and put to use), engages them with this through designing and making and has the potential to open the way for a wider discussion about the purposes to which we put phenomena to use. Again this aligns strongly to the situated view of learning (Murphy, in Barlex, 2003) that supports pupil creativity. The design decisions associated with this task are summarised in Table 3.

Table 3: **A task and design decisions for pupils aged 14 years.**

From the Design and Technology Association Modernization project		
Year	**Task**	**Design Decisions**
Year 9	Peltier Cell Project Design and make a device that uses the Peltier effect to provide a low temperature	The purpose of the device The arrangements to achieve the purpose Who the device is for The appearance of the device
The above task is under development by Philip Holton at Cheam High School		

Conclusion

This paper has shown that the act of designing meets the criteria for creative activities as defined by the report *All our futures: Creativity, culture and education* (Robinson, 1999). The paper has shown that it is possible to audit the design decisions that pupils make using a design decision pentagon

that features five interrelated aspects: conceptual (overall purpose of the design, the sort of product that it will be), technical (how the design will work), aesthetic (what the design will look like), constructional (how the design will be put together) and marketing (who the design is for, where it will be used, how it will be sold). This audit tool can be used to ensure that as pupils become older, design tasks can be set that require more sophisticated design decisions. A key factor in enabling pupils to be creative with such tasks is the way the tasks are taught. The teacher needs to adopt a situated view of learning and share with pupils the responsibility of learning. Recent developments that are being promoted by the Design and Technology Association are enabling teachers to work with pupils in deciding the nature of the design tasks they tackle.

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DISCUSSION

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Q1: My question is about the historical development of this idea of design and technology in UK. Around 1984, there was design and technology curriculum that existed for older students at higher secondary level and one thing I think that has happened is that design and technology has come into the curriculum for younger and younger students. But can you tell us something about the way of looking at design and technology, the educational issues, how the types of activities perhaps have changed. I mean has there been an evolution over the last 20 years? Has the conception of design and technology changed?

DB: Yes, as far as young children are concerned there really was not much design and technology going on in a majority of schools before 1990's. Then we had a national curriculum and every

primary school teacher was expected to be doing design and technology. So that was a good start and then government introduced two strategies, literacy strategy and numeracy strategy, which meant most of time pupils spent a lot of time doing literacy and numeracy. The rest of the curriculum became really squished and design and technology along with other creative subjects became marginalised. So when we developed the Nuffield Curriculum it was a case of what can we do to orient teachers. We made our decision, it had to be something manageable, something affordable and it had to convey some feelings about teachers and pupils. I think there has been development because lots of schools do design and technology now. We have got a new government which is very much going back to basics and this may pose a threat. But I would say teachers in schools where they are doing design and technology are getting better and help the children to like designing and they are becoming better at designing their own tasks suitable for their own situation. A good thing about Nuffield is that it gives you a framework which you can apply. If you see it as a mechanism for evolution, I think it is pretty slow. Because a primary teacher is very busy, and may have a whole lot of stuff to teach and they may not engage with design and technology on their own volition. So it tends to be that if the head teacher is keen on design and technology for schools, it may work out. If not it probably does not. Regarding the conception, I think it has also changed, because I think we have moved from just craft, essentially making to design and technology. Teachers need to be more interested in children's activities and integrate their own ideas. So that depends on the teacher's competence.

Q2: I was wondering how important or rather how unimportant issues of feasibility are in the project's design without making. I ask this, because in science fairs, a distressingly large fraction of the projects are those that definitely sound good to the kids and to the uncritical judges but if you just put them in the numbers even at the zeroeth order, they involve very basic physics that you find won't work.

DB: I think we don't want to live in a fantasy land but you also don't want to be over constrained about the reality. That is the tension. One thing we did in the Young Foresight project was, we had people from industry coming as critical friends and judge the children's ideas. There is a pedagogy there that helps to move a flaky idea to an idea that is okay. We can get innovations to actually work. Most of the ideas pupils developed were quite feasible.

Q3: Did you leave aesthetics as one of the point of consideration while designing and not making. Does the decision making continue throughout the project?

DB: Well I think clearly that the children make aesthetic decisions, but it seems to me that initially when they are coming up with the conceptualisation of the product, asking for aesthetics and usability and so on was asking for too much. Most of the children have very clear views about aesthetics, perhaps I did not make it explicit in the presentation. Yes the decision making is throughout.

Q4: Is there any evidence that where schools spend time doing design and technology it leads to an improvement in literacy and numeracy as well?

DB: There is a little bit of evidence but it's not that robust. The design and technology community is into doing activities in the classrooms rather than doing research about it. I think that's the

interesting thing-- how many design technology researchers are there in the audience here? Perhaps three/four and the science education researchers are so many. One thing I would like to see happen as design and technology teachers talk more to science and mathematics teachers, you can start getting some of the collaborative research going. Actually if you do get this collaboration then it is possible that the Design and Technology task will get some interesting maths and you can use the maths in interesting ways and become better in maths and the maths could help the students become better at design and technology. It's got to be a two-way street.

Q5: Since you have being practising in this area, do you actually see the prospect of teaching the subject at traditional classes the way other classes are done like mathematics and science. Can you think of a context where the construction of design and making can actually substitute completely the traditional way of teaching subjects?

DB: Well a lot of people have written about learning through design but the reality of actually achieving it is far from it. A lot gets in the way with that kind of work and it is back to radical thinking. It is like a teacher thinking that now I am going to make this design the centre of my teaching. In fact some people are saying you should put design and technology at the centre with everything coming around it. I have yet to find a school to have the courage to do that. And it would be a very great thing to do. But certainly I think there is interesting information between classes, you can get some maths and science and design and technology teachers working together, say for a week. Wherein we may not have any lessons as such, and are going to explore something where maths, science and design and technology teachers are doing some tasks and children work through it. That'll be interesting.

Q6: Just to add to some of the discussion that's been going on about whether you can learn subjects through design and technology or whether there is evidence for that, there is a very particular kind of research that's been done in 1990's to 2000 where you get engineering designs followed by science experiments versus science concept learning followed by application and there is clear evidence that engineering design preceding other tasks actually has a lot of benefits. The other question is that the big decision that the teacher needs to make especially, the open starting point task there could be huge variation in the kind of things that students do.

DB: What struck me is that there should be a dynamic relationship between science and technology education. It depends on and it all comes back to the teachers. They are respecting each other's positions and that's important also. To have the time to actually look sideways and see what other colleagues are doing, that is a first step to breaking down this highly stratified curriculum. Regarding variation, part of it depends on how well do you know the children in your class, and teachers need to build trust in the class. And lot of the success and failure lies in this.

Q7: What I see is a lot of opportunities for development of science and ideas and concepts and understanding of science and design and technology. Is there any research being done in that communication between science and design and technology?

DB: Well, I have done some research on that. I wrote about the situation outside schools where there is a dynamic relationship between science and design and technology, but within schools between teachers of science and teachers of design and technology I see that there is often no relationship. It's actually quite difficult to get teachers to talk to one another. I did some work with a friend of mine with science and technology teachers and while doing so, it ended up in arguments between the teachers. Science teachers said what they taught was more important than what the design and technology teachers taught. But it was an important lesson to us. How do we actually get people coming to a common ground and valuing each other? We know that science provides explanations and we can try to work out some things for ourselves. How does that play out if we want to use that explanation in design and technology? What we want to avoid is a science teacher teaching bad design and technology and a design and technology teacher teaching bad science. So it's complicated.