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Title
The centrality of designing – an emerging realisation from three curriculum projects

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Introduction
Kimbell and Perry (2001) have presented a powerful case for the significance of designing within the design & technology curriculum yet although design activity is implicit in design & technology national curriculum for England (Department for Education and Employment, Qualifications and Curriculum Authority 1999) the words design or designing are not used in the unique contribution statement which justifies the inclusion of the subject in that curriculum. This paper describes the role of designing within the design & technology curriculum in England from the perspective of three curriculum projects over 15 years: a) the Nuffield Design & Technology Project which developed a pedagogy to enable pupils to be successful at designing and making simple products, b) the Young Foresight Project which developed a pedagogy to enable pupils to tackle conceptual design and c) the Electronics In Schools Project that enables teachers to consider progression in the construction of a design based technology curriculum involving electronics. Finally the paper discusses the role of designing within a design & technology curriculum in which both designing and making occur and argues that it is engaging in design that is the key to the unique contribution that can be made by design & technology to the education of all young people.

Pedagogy to support designing and making
The Nuffield Secondary Design & Technology began in 1990 as design & technology was introduced as a new subject into the National Curriculum in England (Department of Education and Science / Welsh Office 1990). By 1995 the Project had developed pedagogy in response to the demands of designing and making that formed the core of this design & technology curriculum. The pedagogy consisted of three types of learning activity. Resource Tasks, short often practical activities that taught specific skills, knowledge and understanding likely to be useful in tackling a designing and making activity; Capability Tasks, longer more open designing and making activities; and Case Studies, true stories about design & technology in the world outside school to enable pupils to put their studies into a wider context. Through a careful combination of these types of learning activity across a number of years a teacher could construct a learning experience that was broad, balanced, covered the required programme of study and met the requirements of continuity and progression. A suite of publications were developed to support teachers in using this pedagogy: a Resource Task

File (Barlex, 1995a), a Capability Task File (Barlex, 1995b), a Study Guide (Barlex, 1995c) containing both advice to the pupil and an extensive set of case studies, a Student's Book (Barlex 1995d) which defined the content with which pupils should be familiar and a Teacher's Guide (1995e) to provide advice in using the materials. As is the case with much curriculum development, the content of these works derived largely from listening to teachers, limited piloting and the Project Director's intuition, but an analysis of the content (Barlex and Welch 2001) shows that the materials leant heavily on the work of the Assessment of Performance Unit for Design & Technology (Kimbell, Stables, Wheeler Wosniak & Kelly,1991) and had considerable resonance with the work of Welch et al on the behaviour of naïve that is, pupil designers (Welch, Barlex & Lim, 2000). There is little doubt that the pedagogy developed by the Nuffield Project was new to many teachers. To the delight of those associated with the Project the revision of the National Curriculum for design & technology in 1995 included key features from the work of the Project – focused practical tasks (i.e. Resource Tasks) and designing and making assignments, DMAs (i.e. Capability Tasks).

A questionnaire survey to probe the use made of the Nuffield publications (Givens & Barlex 2001) revealed the following. The most widely used were the Student's Book and the Resource Tasks. It may be relevant that both were easy for teachers to use selectively without necessarily changing their practice. However, the task structures were used nearly as much as the tasks themselves, but as frameworks for schools' own in-house materials. The task structures embody the pedagogy behind the materials ('the Nuffield Approach') through, for example, detailing activities (Resource Tasks and Case Studies) that will prepare pupils for a Capability Task and indicating value considerations and links to other subjects. When teachers adopted the task structures but not necessarily their content, were they, in fact, adopting the pedagogy and applying it to their pre-selected content? Becher (1971) relates how teachers adopted the content offered by a curriculum innovation but retained their existing (didactic) teaching methods. The findings appeared to show some teachers responding to accessible structures in the opposite way, i.e. adopting the pedagogy from a curriculum innovation while retaining content from their established practice. Although some teachers used the Nuffield approach in ways that would enable pupils to design what they were going to make and then make what they had designed this was not a National picture and the Office for Standards in Education consistently reported that skills in designing lagged behind those in making (Office for Standards in Education 1998 & 2000). Atkinson (2000) has noted that the assessment structure militates against the development of higher order thinking skills associated with designing.

A particularly interesting feature of the Student's Book are the chooser charts, which were developed deliberately to support pupil autonomy in making design decisions and solving emergent problems. The book contains 12 such charts which summarise areas of content in such a way that pupils can use the content

to make decisions either unaided or with minimal support from their teacher. An able pupil can use such charts to make decisions, which he or she can then justify to the teacher. For a less able pupil the teacher can ask questions, which engages the pupil with the content of the chart, so leading the pupil to make their own decisions. Of course the best way to use such a chart involves annotating the chart with possible choices by drawing circles, adding ticks or crosses and notes. To promote such use of these charts they are available as free downloads at www.secondarydandt.org the Nuffield Secondary Design & Technology Project website.

Pedagogy to support conceptual design

Insisting that pupils should always make what you have designed can undermine pupils' autonomy especially if they have limited making skills. The Young Foresight project deliberately avoids 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, 2000). To facilitate this activity pupils are required to work as groups in which all members contribute to generating, developing and communicating design ideas. Importantly pupils are required to develop their own design briefs and mentors from industry work in a variety of ways to support pupils designing for the future. And pupils are required to present and justify their ideas to peers, their teacher and mentor, and to audiences at conferences on innovation.

Some of the products and services devised by groups of Year 9 pupils in response to the challenge of utilising the stress sensitive conductor QTC (Quantum Tunnelling Composite) include the following:

- Clothing that change 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 report All our futures: Creativity, culture & education (Robinson 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.

Through her evaluation of the Young Foresight Project Patricia Murphy identified two broad categories of teacher pedagogy (Murphy in Barlex 2003). First there was the pedagogy that was hegemonic:

- 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 instruction and school focused
- Any problems with learning rest with the learner, not the teacher i.e. a deficit view of pupils limited by their innate abilities

Second there was the pedagogy 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 pedagogy taught in ways that were at odds with the Young Foresight programme. They struggled to implement the programme and undermined its aims. Pupils' participation was marginalized and there were few opportunities for pupils' learning. Pupils were not motivated by the experience.

Those teachers with the second pedagogy were able to be highly effective in implementing the programme. There was significant learning and pupils in these teachers' classes were enthused and motivated by their experience of the programme.

Elaborating design decisions

The Electronics in Schools (EIS) Project involved collaboration between a government agency – the Department for Trade and Industry, a curriculum developer David Barlex acting as curriculum adviser, a researcher Patricia Murphy at the Open University, and SETPOINTs – organisations charged with providing support for STEM (science, technology, engineering and mathematics) in the school curriculum. (See www.setnet.org.uk for further information). In an effort to promote the teaching of electronics in schools the DTI funded seven SETPOINTs to explore ways in which teachers could receive in service training that would lead to an increased teaching of electronics in design & technology courses. Initially the professional development made available by the SETPOINTs consisted almost exclusively of providing subject knowledge. Under the influence of the curriculum adviser the training sessions were revised to include a consideration of pedagogy and how to introduce change in the participant's schools. The nature of the in-service programme and its impact on the design & technology curriculum, teachers and pupils in participating schools was evaluated as the programme was taking place by Patricia Murphy and her team at the Open University. Her evaluation report is available from the EIS Project website. www.electronicsinschools.com/about_eis/index.asp

The evaluation notes the positive effect of providing teachers with the opportunity to engage themselves in the sort of activity that their pupils will be doing, designing and making assignments, and a design decision audit tool that allows teachers to analyse these tasks from two perspectives (i) the opportunities for pupils' learning and (ii) cultural authenticity. The audit can be carried out using five key areas of design decision: 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 interdependence of the areas is an important feature of design decisions. 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. 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. Consider the designing and making of a puppet theatre and puppets. The pupils can make decisions about who will use the puppets and what for (marketing decisions), what sort of puppets would be appropriate, the sort of theatre such puppets would need, the nature of props and scenery plus any special effects that might accompany the performance. These decisions will encompass a host of technical, aesthetic and constructional design decisions.

Designing – a central feature for technology education for all in the future
A pupil designing speculates about what might be. These speculations are developed, modelled, evaluated for fitness of purpose, realised as a prototype, and evaluated further against intention and impact. The design problem interacts with the design solution, elements of both the problem and the solution only becoming apparent as the solution is developed in response to the problem.

An intriguing way of looking at this problem – solution interaction is to consider the designing as a learning activity in which the designer is learning about the design that he/she is conceiving through successive iterations that give increasing clarity to the design proposal and its worth (Sim & Duffy 2004). The designer is learning about what he/she is creating as he/she creates it. From a pedagogic viewpoint this is fascinating – it is the pupil who has the knowledge and expertise in this situation, only he/she knows about his/her design. The teacher's role is one of enabling that learning to progress according to the pupils design intentions. This is very different from the traditional role of the teacher which is to help the pupil learn about that which the teacher already knows.

One of the problems facing the teaching of designing is the peculiar nature of the subject matter of design. Design has no special subject matter of its own apart from what the designer conceives it to be. The subject matter of design is potentially universal in scope because design thinking may be applied to any area of human experience. But in the process of application, the designer must discover or invent a particular subject out of the problems and issues of specific

circumstances. It is possible to tackle this dilemma in schools to some extent by considering ‘knowledge of the problem’, which can be acquired by pupils through investigation and research and ‘knowledge for the solution’, which can be identified to (say) between 50% and 75% for a particular set of solutions and hence taught in a traditional way.

The Nuffield Project has developed a broad pedagogy which deals with this dilemma – Resource Tasks which support the acquisition of ‘knowledge for the solution’ leading to a Capability Task (a designing and making task) in which pupils identify ‘knowledge of the problem’ and work towards a solution acquiring any more ‘knowledge for the solution’ that they might need. Case Studies provide background information relevant to ‘knowledge of the problem’. It is highly likely that resolving the task will require knowledge and understanding from other subjects hence designing is a powerful means of crossing and breaking down subject boundaries. Furthermore, the Nuffield Project has developed pedagogic devices that overcome pupils’ lack of ‘knowledge for the solution.

The Young Foresight Project revealed that it is not always necessary to design AND make and that pupils can develop a wider appreciation of and ability in designing if sometimes they can design without having to consider making. The Young Foresight Project has also indicated that positioning designing at the core of a technology curriculum will be highly challenging for some teachers. It has been argued that teacher’s implicit beliefs inform their prevailing pedagogy (Dow 2003, 2004). Teachers whose implicit theories of learning are governed by notions of transmission of knowledge and control of learning will find it hard to create the type of structures which will encourage designing, however the importance of this is espoused. Implicit theories appear to play a significant role in the way teachers choose to teach. Revealing and confronting these theories is neither easy nor comfortable but it would appear that it should become an essential part of both initial teacher training and subsequent professional development if designing is going to be significant in technology education.

The EIS Project has shown that it is possible to audit a curriculum composed of designing and making assignments according to the demands of design decisions and so give designing, as opposed to making, the high priority required to ensure that the activity is cognitively demanding without demotivating pupils.

Hence I argue that the role of making though important is not central to technology education. Manufacturing technologies capable of generating complex 3D forms both solid and hollow are already finding their way into some schools and it is likely that these will be available for the domestic market before long (Massachesetts Institute of Technology, September 2003). The issue is not whether a pupil can make what they have designed but whether it is worth making. This is not to devalue making. It will be essential for pupils to handle materials, to use both hand tool and machine tools as part of their making experience in order to design appropriately with particular materials. But this

making should be in deference to the act of designing. It is designing that will develop pupils high level cognitive skills through which they will be able to handle uncertainty, seek out relevant knowledge, solve problems, make and justify decisions and communicate effectively. These are qualities that will serve young people well whatever career path they choose.

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