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Modelling in Key Stages 1 and 2

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Abstract
The recent production of a new Open University certificate module in Primary Design and Technology provided the opportunity for some extended filming of primary school children engaging in a range of modelling activities. The paper will present a view of modelling in a technological context that has been arrived at in part from detailed observation and analysis of this video material.

The view is that modelling

a) has a range of distinct purposes (e.g. communicating, evaluating, etc.) and
b) has distinct kinds (e.g. 2D, 3D, symbolic, etc.)

and that unless these purposes and kinds are distinguished at least in the teacher’s mind, some of the most valuable teaching points will be lost.

Using the purposes and kinds as an analytical framework then enables a range of models and modelling media to be analysed as to their suitability and an assessment of modelling in the design and technology order to be made.

Paper No.1

Introduction
Modelling is a key technological process and, as such, finds considerable representation in Open University Technology Faculty courses, some of which may also be familiar to teachers (e.g. O.U. 1983, 1988). The current generation of courses on technological education (e.g. O.U. 1987, 1992a, 1992b) pick up the centrality of modelling not only in the context of technology in the world, but also as an essential feature of children’s development of technological capability. When the National Curriculum Design and Technology proposals were in their consultative stages, it was the issue of modelling (as needing a coherent and structured treatment) that was one that we raised more than once. Some of my recent work has been developing case studies of primary school children engaged in design and technology activities, and I am more convinced than ever of the need to raise understanding by teachers of the importance of modelling within technology.

Establishing an analytical framework
As with most words that have specific meanings within technology, we have to recognise that there are everyday uses for these words that do not carry the full weight of meaning appropriate to a technological context. In this paper, I am assuming that

a model is a simplified representation of something created for a particular purpose.

The critical question to ask about a model is, therefore, for what purpose is it intended? Indeed, this intention will determine the nature of the model, against which the usefulness of the model will be evaluated. Because of the diversity within modelling it is helpful to identify various distinct purposes and kinds of modelling within technology. I shall do little more than name these initially - the categories should become clearer as they are used in subsequent analysis.

Purposes for modelling
* helping with thinking
* communicating form or detail
* evaluating a design or selected features of it

There are inevitably overlaps between these, but it does help to distinguish the purposes because, as has already been said, the usefulness of a model depends in part on the purpose for which the model was intended.
Kinds of modelling

There are various ways of identifying the kinds of modelling, but for the present paper I want to focus on four kinds as follows:

* two-dimensional (2D)
* three-dimensional (3D)
* symbolic
* computer

This list is by no means exhaustive, and it is quite possible for a given model to be simultaneously of several kinds.

2D modelling includes drawings and computer graphics, whereas 3D modelling will include kit and other construction methods enabling the fabrication of a form occupying space. Symbolic modelling uses a symbol to represent something: for example, the same symbol can represent an electrical switch or a door, depending on its context. Computer modelling is increasingly common in schools and in the world beyond, and includes such things as spreadsheets to handle mathematical functions which can, in turn, be used to model economic and technical aspects of technology. In focusing on Key Stages 1 and 2 I have chosen not to identify mathematical modelling as a specific kind. Purists should be happy to include it under symbolic modelling, anyway!

Applying the framework to references to modelling in England/Wales D&T Key Stages 1 and 2

Table 1 shows how modelling is represented in the England/Wales statements of attainment for Key Stages 1 and 2. Some of the references are explicit - i.e. a function or kind is named - whereas others are implicit - i.e. their use is evident but not named. The evidence is that modelling is pervasive but is not included in a structured way.

Table 2 shows my view of how the functions and kinds of modelling feature in the above statements. I believe that if more effective use is to be made of modelling in the development of children's technological capability, an attempt must be made to analyse the use of modelling through purposes and kinds such as I have suggested. If this is not done, it is difficult to identify strands of progression and, therefore, difficult to enable children to develop their ability to model effectively. Perhaps most critical is an acknowledgement that most making in schools is actually modelling, except on those occasions when a one-off artefact can be recognized as the equivalent of something made in the circumstances of a craft workshop.

### Table 1

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Key:
(1) explicit reference in statement of attainment
(2) explicit reference in an example
(3) implicit reference in statement of attainment
(4) implicit reference in an example
Hats and houses: examples of children modelling

Preparing the video sequences to accompany the Open University's new Certificate Module Design and Technology in the Primary Curriculum (O.U. 1992a) provided the course team with the opportunity to observe and reflect on the way that children work when they are designing. We were particularly struck by the importance of modelling as an aid to these children's thinking, and were caused to think especially about the relationship between 2D and 3D modelling and the difficulties that children can experience if insufficient thought is given by the teacher to the complexity of transitions between the two.

Hats

We observed top junior children making prototypes of hats to be considered as an addition to their school uniform, with the particular feature of high visibility. All the children had brought an example of a hat to school - 80% of these being variations on the popular baseball cap. The children were asked first to draw up a simple specification for their proposed hat and were prompted to think of aspects such as colour, style, water-resistance, etc. Most of the groups subsequently designed hats based firmly on one of the available examples, and sketched their intentions, but when it came to 3D modelling, all the groups floundered. Some genuinely seemed to think that, if they drew round a hat (producing an elliptical shape on a piece of card), this would somehow make a hat shape. Their ability to sketch in 2D their intentions for a 3D artefact appeared to be unrelated to their ability to draw any kind of 2D pattern or net that would make up into the required shape. So the drawing (so often required by teachers as a first stage) didn't help with the 3D modelling. The group that had most success worked by trial-and-error, starting with a paper circle, and then shaping it round someone's head by making one, then two, then four cuts (in the paper, rather than the head), and finally adding a peak. In other words, it was modelling in 3D that enabled the children to do their design thinking. Another group had a clever idea of forming a 3D framework out of three flattened art straws, joined at their centres. However, when they came to cover this framework with a textile offcut, they went back to working in 2D on the table top, not seeming to realise that the textile wouldn't simply bend from a flat circle to a hemisphere. Such difficulties lead us to believe that there are some occasions when asking children to plan in 2D something that they are going to model in 3D is not the most helpful approach.

Houses

We filmed several groups of infant children making small-scale models of houses. The starting point for one class was a story that led the children to want to make a house for a teddy. The approach was through furnishing a range of boxes: boxes being selected to be a suitable scale for a chosen teddy - a big box for a big room etc. Plans were drawn after the rooms were furnished, and these children had little difficulty in making these plans by looking down on their boxes. The 3D modelling - 2D modelling sequence

Table 2

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here seemed eminently suitable i.e. do your design thinking in 3D and then record the outcome in 2D if you have a reason for so doing.

The starting point for groups in another class was their “ideal house”. These children were asked first to draw plans of their own homes by imagining what they would see if they were able to hover over the house with the roof removed. Most could visualize this, with some puzzlement over stairs. They were then asked to draw 2D plans of the room layout of their ideal house, and groups were then allocated a range of media with which to make 3D models. Commercial kits of Lego and Quadro were available; other groups used frameworks of glued wood with card corners (subsequently covered with walls made of card), and one group used cardboard boxes. It was interesting to observe the advantages and disadvantages of each medium in terms of helping the children to think out their designs. It was also interesting to observe the puzzles that arose from translating 2D plans into 3D models.

Lego was fairly straightforward, in that it allowed a “ground up” approach. Bricks were laid as foundations for walls following the 2D plan. Design decisions had to be made about the height of walls and windowsills. Quadro proved less flexible in this context as it constrained the shape of rooms (cutting components was not allowed). By comparison with Lego, where the shape emerged from the ground, it was necessary for the children to have a clearer initial picture in the minds eye of the 3D shape they were aiming for. Selecting the correct joiners for various meeting points of struts was a great puzzle and usually accomplished by trial-and-error rather than by any predictive strategy.

The group using cardboard boxes found initial difficulty with the idea of matching available box sizes, or adapting boxes, to their intended room sizes. We wondered if an initial exercise of the “teddy’s room” kind (i.e. 3D leading to 2D rather than vice-versa) would have helped them to visualise what was required. The groups using wooden frames and card corners, with the framework subsequently covered with card to form walls, had all kinds of problems with orientation as they were making and covering the frame. In this last case, the 2D plans were hardly referred to, and we wondered just how helpful they were.

When we had finished observing the making of these houses, we set about analysing the uses made by the children of the functions and kinds of models that are identified earlier in this paper.

Applying the analytical framework to the houses
During the building of the houses, the emerging structure was a 3D model helping with thinking. Evaluation took place of aspects of the model as it took shape, and mistakes were rectified as they were discovered, and improvements made as required. A final evaluation was carried out in part against the original specification of room layout on the 2D floor plan (perhaps the only really valuable use for the plan). As we have observed above, the modelling media exhibited particular strengths and weaknesses as regards the functions that the modelling was serving. Some helped the children more than others in particular respects. When the houses were complete, they served the purpose of communicating the children’s intentions for their ideal houses to the other children and to their teacher. So the function of the model was different at different times. When it came to this final function of communication, the non-kit media proved to have the advantages that they could be a (more effectively finished to look like “real” houses and b) kept.

We felt that an appropriate sequence for these young children may have been:

* use Lego to think out your design for your ideal house
* use a more permanent medium to make a corresponding model that you can detail and keep
* make 2D plans and a sketch of what you have drawn.

Concluding thoughts
I wonder if, sometimes, the sequence design-realise, or draw it-make it, is inappropriate for those learning how to design through modelling. It would be interesting to set up an investigation that compared two groups of children carrying out activities as described above: one group being asked to draw then make, and the other being asked to model in 3D from scratch. Quite clearly, part of technological capability is being able to design in a predictive way, rather than by trial and error. But young children do not as a rule have the resources to enable predictive designing. Modelling in 3D in a range of media is surely one of the most important ways in which the resources that enable predictive design can be built up. When the technology curriculum is reviewed, I believe it is as important as ever to establish a firmer
rationale for the use and teaching of modelling as children develop their technological capability.

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