The Nuffield approach to the teaching of mechanisms at key stage 3

Dr D Barlex and N P Givens
Nuffield Design and Technology Project and University of Exeter

Abstract
Mechanical control has been a significant and popular aspect of technology education throughout it's recent history in England and Wales. It has had a clear place in the latest national curriculum programme of study for design and technology.[1]

The Nuffield Design and Technology Project takes a systematic approach to giving pupils the resources to design and make, together with opportunities to develop design and technology capabilities through applying these resources.

In establishing the "what" of learning about mechanisms, the project has sought to identify knowledge and understanding which pupils are likely to need, and be able to apply, in the course of their designing and making. In addressing the "how", the project has developed teaching and learning approaches which engage pupils in identifying, selecting, designing, modelling and making mechanisms to fulfil a specification. This paper gives a detailed account of these approaches, and the rationale behind them.

The Nuffield Design and Technology Project

The Nuffield approach to Design and Technology states clearly that capability requires pupils to design what they are going to make and then make what they have designed. This has clear implications for teaching. Pupils will need to learn technical knowledge and understanding, design strategies and making skills. The Nuffield approach teaches pupils these resources for capability through short, structured activities called **resource tasks**. It is insufficient to simply acquire these resources. Pupils need to learn how to use them in designing and making. The Nuffield approaches uses **capability tasks** for this purpose. These are more open ended designing and making tasks which have been designed with three key requirements in mind, namely managability (in terms of resources and the range of activities that a teacher has to support at any one time), provision for differentiation, and empowerment of pupils to succeed . As there is more to design and technology than pupils' own designing and making the Nuffield approach uses **cases studies**. [2] to provide for a balanced and constructively critical view of design and technology in action. This paper will describe how the approach has been applied to teaching and learning about mechanisms, with a particular focus on resource tasks.

Defining a conceptual framework

The Project had discussed at length with various parties how best to give pupils an appreciation of mechanisms. For some it was familiarity with as many different mechanisms as possible perhaps reflecting the view of Robert Fulton in the 18th century [3].

> The mechanic should sit down among levers, screws, wedges, wheels etc. like a poet among the letters of the alphabet, considering them as the exhibition of his thoughts, in which a new arrangement transmits a new Idea to the world.

For others it had to based firmly in a systems approach and was in some cases taken to a black box extreme in which the nature and behaviour of individual components was seen as irrelevant. Discussions between David Barlex and Nick Givens led to a compromise position which if successful would enable

pupils to adopt a systems view where appropriate but would also allow pupils to make design decisions based on individual components. The Project presented this conceptual framework under the following headings :
Changing the type of movement
Changing the direction of movement
Altering the axis of rotation
Increasing output speed and decreasing force
Increasing output force and decreasing speed
Applying and maintaining a force
Transmiting movement and force.

Any mechanisms or mechanical systems are likely to include several of these functions. The aim of the framework is to provide pupils with a way of looking at both familar and unfamilar mechanisms and asking themselves "What does it do ?" The Project thought that it was important to show examples of each of the above functions in real products and to develop a means of annotating these products with symbols to indicate types and directions of movement, alterations in axis of rotation and changes in both speed and force. The aim here was for pupils to learn to use the symbols in describing the behaviour of existing systems and then to apply them in designing systems themselves.

Tasks to establish the conceptual framework

The Project's view is that pupils will be more likely to acquire technical knowledge and understanding if it can be embedded in a practical experience. The first experience in learning about mechanisms, however, should not be to try and design a mechanism. Discussion with teachers in trial schools and with equipment suppliers had revealed that an "in at the deep end" approach did not work. In response, the Project produced a set of familiarisation tasks designed to introduce pupils to thinking about mechanisms in terms of the conceptual framework which is characterised by the headings outlined above. The key features of the tasks were that they should be:

- short
- involve actively exploring mechanisms
- encourage pupils to think in terms of input and output
- teach pupils to use the annotation symbols.

The Project worked closely with Richard Sykes of the educational supplier Economatics [4] who produced a range of mechanism models using Fischer Technic construction kit components. These models mirrored precisely those illustrated in the tasks. Trial versions of the tasks were discussed with teachers on in-service training courses [5], and in response the main introductory task was divided into three, and the wording of instructions was made more precise. Trialling in schools [6] led to the introduction of another feature - giving pupils guidance and practice at the rapid sketching of mechanisms (rather than time consuming, detailed drawing).
The set of introductory tasks finally published was as follows:

MRT1 - Changing types of movement
MRT2 - Changing axis and direction of rotation
NRT3 - Changing force speed and distance
MRT4 - Spot the mechanism
MRT5 - Mechanism flick books

The Project has only limited feedback on these tasks but one response is particularly noteworthy. Peter Reeves of Charterhouse School [7] has told us that he uses this set of tasks to introduce KS4 pupils to mechanisms. For a variety of reasons many of these boys have little or no experience of mechanisms at KS3. Peter uses the task sequence over one week and finds it an extremely efficient way of introducing/revising basic concepts.

Assembly experience

The Project's view is that pupils need experience of assembling mechanisms before they can apply their technical understanding to designing and making mechanisms. It is also important that this experience moves the pupil away from assembling with kits of parts that have been designed to be fitted together and then taken apart. To provide an intermediate position between using a construction kit and designing and making from scratch (albeit using bought in components) the Project produced two "assembling mechanisms" tasks. The first involves a simple cam and slider with 12 pieces and the second a more demanding combination of cam and crank with 25 pieces. In discussing these tasks with trial schools it became clear that many would want to purchase inexpensive sets of parts ready prepared rather than preparing the parts themselves. The Project has liaised closely with Tony Beardshaw of Technology Teaching Systems [8] and kits for each of these tasks will be available in September 1996.

Work between Richard Fenwick at Bilton Grange School [9] and David Cook Martin of the educational suppliers Unilab [10] has led to the interesting development of the models for teaching the conceptual framework being made from Polymek. Polymek is not a construction kit where preformed parts are put together, rather it is a manufacturing system where the user makes the parts using a family of materials which are fabricated using versatile jigs and tools. Richard Fenwick has developed his own assembly tasks using Polymek and this has led to pupils aged 10 and 11 years being able to make simple mechanisms similar to those they investigate in the introductory tasks.

Derivative designing and making

The Project's view of enabling pupils to design and make is that there will be times when it is appropriate for pupils to develop designs that are very strongly based on existing designs. The work of Richard Fenwick [9] in mechanical toys adopts this approach. The highly attractive results can be seen to be derived from a visit to the Mechanical Cabaret in Covent Garden but, none the less, show ingenuity, good craft skills and interestingly, considerable differentiation. The Project worked closely with the teachers at Sarah Bonnel School in Newham [11] in trialling a capability task called 'Times Past'. In this task pupils were asked to consider the life of a child in Victorian Times and design and make facsimile toys that could be sold at a museum shop. Several pupils concentrated on optical toys and produced working zoetropes. Albeit derivative designing and making, the work of one girl in particular shows the value of this. Tackling the mechanisms in the flick books had given her an insight into computer animation and she used graphics software to produce an elegant tumbling clown for the zoetrope.

A view of progression

The Project's view on progression in technical understanding is characterised by the following steps :

from qualitative appreciation, acquired through simple vocabulary tasks,
through qualitative application, acquired through simple step design and design scenario tasks,
to quantitative appreciation, acquired through more demanding vocabulary tasks,
to quantitative application acquired through more demanding step design and design scenario tasks.

The Project believes that this progression will be achieved through a sequence of resource tasks which engages pupils with each step in turn. Twelve of the thirteen mechanisms resource tasks in the Nuffield KS3 materials are concerned with the first two features of progression; qualitative appreciation and application. The thirteenth task is a series of quizzes designed to engage pupils with quantitative appreciation. [12]

It is important that pupils use their understanding of mechanisms in complete designing and making assignments and the Project has been pleased to receive very positive feedback from Peter Reeves [7] concerning a capability task which involves the designing and making of weighing machines. This clearly requires quantitative understanding and application (eg in considering the range, resolution, deflection of the scale pointer, calibration). Monitoring of the effects of resource task sequences on pupils' technical designing is planned to take place over the next year.

Justifying design decisions

One of the key features of the Nuffield approach to design and technology is the provision of "chooser charts" which summarise information useful for making design decisions. They were developed because teachers expressed some difficulty in helping pupils to develop design ideas. Two extremes of position were encountered - "You

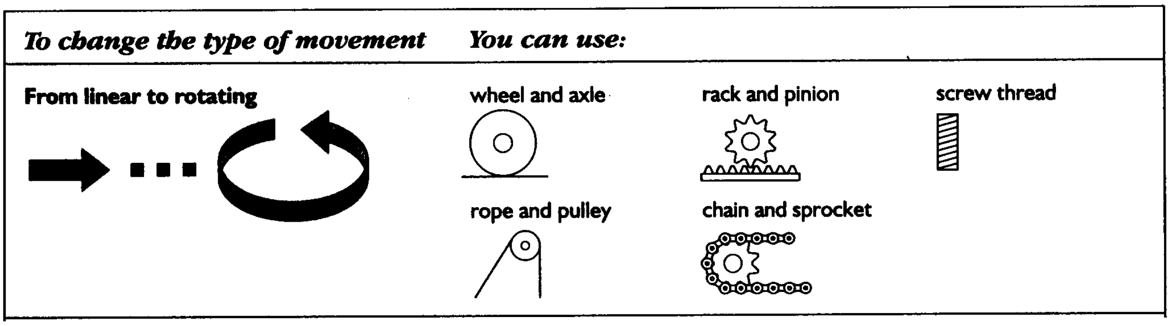

Fig. 1 Part of the Mechanisms Chooser Chart, from the Student's Book (13)

must try and think of something" and "Why not use this." The charts provide a half way house in giving a range of possible solutions (see figure 1).

When a pupil makes a provisional choice, guided by the chooser chart, the pros and cons of that choice, an evaluation can be discussed. The choice can be rejected without too much concern because there is a page full of alternatives. A pupil can be asked to consider the pros and cons of a particular choice as a means of starting the thinking. The teacher can suggest more or less complex selection criteria with different pupils according to the sophistication of the design thinking required. What has become apparent from the limited feedback we have received is that it is the quality of conversations that the charts provoke that is the key to their successful use. It is here that the role of the teacher is so important. The Project hopes to track the use of chooser charts by both pupils and teachers over the next year.

References

1 DFE. Design and technology in the national curriculum. HMSO, London (1995).

2 Barlex,D. *Nuffield Design and Technology Study Guide,* Longman, Harlow (1995)

3 Hindle, B. *Emulation and Invention* New York University Press, New York (1981) .

4 Economatics Education Ltd, Epic House, Sheffield, S9 5AA, England.

5 Jealous,J. Design and Technology Inspector for Norfolk County Council. Private communication (unpublished).

6 Harrison, G. Nottingham Trent University, Nottingham. Private communication (unpublished).

7 Charterhouse School, Godalming, Surrey, GU7 2DX, England.

8 Technology Teaching Systems, Park Road, Chesterfield, S42 5UY, England

9 Bilton Grange School, Dunchurch, Rugby CV22 6QU

10 Unilab, The Science Park, Blackburn, BB1 3BT, England.

11 Sarah Bonnel School, Deanery Road, London E15 4RS

12 Barlex, D. The Nuffield approach to the role of tasks in teaching design and technology in *Teaching and Learning Technology* Addison Wesley ed Robert McCormick, Patricia Murphy and Michael Harrison.

13 Barlex, D et al. *Nuffield Design and Technology Student's Book*, Longman, Harlow, (1995).