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# Developing information skills and system thinking: a resource-based approach to electronic control systems

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## Abstract

*This paper describes a curriculum development project that addresses the following issue: is it possible to engage pupils in procedures for developing an electronic control system which mirror those of professional engineering?*

*In particular, two key aspects of professional practice were felt to be of critical importance. Firstly, engineers spend a great deal of time evaluating the potential of devices using data sheets. A major part of the development was concerned with developing data sheets for the units of a commercially available electronics systems kit.*

*Secondly the development sought to emphasise system thinking by encouraging pupils to systematically plan their overall system, investigate possible sub-systems, conduct practical investigations and, only then, explore the detailed components required.*

*The paper describes the outcome of the extensive school trials and presents the published materials.*

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## 1. Introduction

This paper describes an innovative approach to the incorporation of work on electronics within design and technology. It seeks to support the progressive and systematic development of the knowledge and skills of pupils in this area and to achieve this in a way which is consistent both with industrial practice and with providing pupils the freedom to produce a wide variety of different electronic control systems, dependent on the 'context'.

The current (1990) English and Welsh national curriculum requirements for design and technology<sup>1</sup> make very little reference to electronics; the only explicit reference is at level 10 i.e. only for the most advanced pupils. Though the document makes extensive reference to 'systems', schools have largely sought to satisfy this by work on organisational systems. The recent proposals for revision<sup>2</sup> make extensive and explicit reference to electronics for control purposes. Though the development described in this paper predates both the original national curriculum requirements and the revision, it is broadly consistent with the proposed revision. Some aspects of the development raises points of concern for the proposed revision.

## 2. History of the development

The Microelectronics Education Programme<sup>3</sup> ended in 1986 and, in its place, the UK government established a new body: the Microelectronics Education Support Unit (MESU)<sup>4</sup>. During its first year MESU conducted an extensive survey of the

perceived priorities of local education authorities with regard to curriculum development, training and support. Within a predictably long shopping list two important requirements emerged in the technology area of the curriculum: computer aided design and work with electronic systems.

The present development<sup>5</sup> emerged from this initial request. The development was based on a three-way partnership between MESU (which was later merged with the Council for Educational Technology and became the National Council for Educational Technology - NCET), the Technology Education Development Unit at Salford University and Unilab.

The writing team consisted of the present authors together with Tim Brotherhood (Staffordshire Design and Technology Education Programme), John Eaden (Tameside LEA), Alan Giles (Trent International Centre for Schools Technology) and David Thomson (Hereford and Worcester LEA).

## 3. Key aims

In defining the fundamental framework of the development, the writers were concerned to engage pupils in procedures for developing an electronic control system which mirror those of professional engineering. It is undoubtedly difficult to characterise the wide variety of 'professional practice'. Figure 1 is an attempt to describe some key issues in the design and development of an electronic system.

The diagram is an attempt to communicate at least

some aspects of the reality of engineering - that, as a project proceeds, greater and greater levels of detail are considered until, at the testing and evaluation phase, wider and wider system boundaries are again drawn.

Of course, any diagram of this kind risks oversimplifying reality. Sometimes the development of

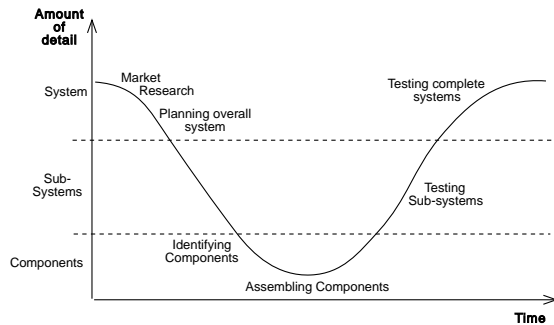


Figure 1

a new component is the key that unlocks a potential major application. But we would submit that the diagram is a reasonable representation of engineering development activity, even if it neglects important issues that the engineer needs to take into account e.g. production, quality control and environmental impact.

Within this concern to mirror professional practice, two key aspects were felt to be of critical importance. Firstly, engineers spend a great deal of time evaluating the potential of devices using data sheets. A major part of the development was concerned with developing data sheets for the units of a commercially available electronics systems kit. It was necessary to make a decision, at an early stage in the project, in the systems kit that would be supported. The initial enquiries of MESU had established the System Alpha (manufactured by Unilab) was most widespread in LEAs at that time. Accordingly, data sheets were developed for virtually all System Alpha units with the twin aims of developing pupils' information handling skills and their knowledge of electronic systems.

Secondly the development sought to emphasise system thinking by encouraging pupils to systematically plan their overall system, investigate possible sub-systems, conduct practical investigations and, only then, explore the detailed components required. We recognised that, while it was essential to support the 'full' process of design and manufacture (including producing a printed circuit board - PCB) as summarised in Figure 1, it would also be important to provide a 'fast' route to producing a working electronic control system, without manufacturing a PCB. There are two reasons

for this. Firstly time in schools technology is always at a premium. Secondly, the reality of Figure 1 is that the engineer engaged in this process is *already* experienced with and knowledgeable about a variety of electronic sub-systems; we needed to provide that kind of experience. The solution was a 'fast' route, shown in Figure 2.

The key distinction between the 'fast' route and the full process is that in Figure 2 the pupil's final solution is a combination of System Alpha boards -

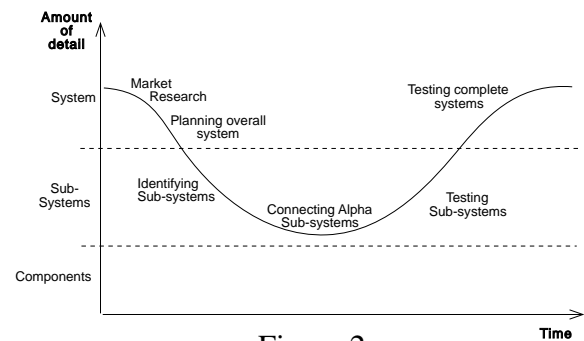


Figure 2

rather than a manufactured PCB.

#### 4. Approach adopted

In order to provide a progressive and structured introduction to electronic systems it was considered essential not to overwhelm the pupil (or teacher) with too many sub-systems at an introductory level. Instead a three level scheme is suggested. This scheme is intended to be appropriate for a scheme of work for pupils over the age range 11 - 16 i.e. up to the end of compulsory schooling in the UK.

It should be noted that the 'levels' we have used are not national curriculum levels. At each level the teacher makes available to pupils a gradually expanding sub-set of System Alpha units. In addition, for each level there are a set of photocopyable sheets to support pupils. The different types of sheets are:

- Guide Sheets - these are retained by the pupil and give a simple overview of how to solve problems with System Alpha and how to use the other publications within the resource.
- Information Sheets - these are general purpose sheets which cover issues such as: an introduction to systems, choosing an input, process, driver or output, fitting Alpha boards together, fault finding, producing a printed circuit and understanding signals.
- Data Sheets - explain the function of each unit. These sheets (together with Investigation Sheets) form the bulk of the resource. The Data

sheets have a common structure with key basic information at the beginning.

- Investigation Sheets - suggest practical investigations that help pupils to understand how to use the Alpha units.

In addition, the resource contains ideas on using combinations of Alpha units for measurement within both technology and science, together with explicit ideas for scientific investigations. There is also a Teacher's Manual.

## 5. Schools trials

The materials were trialed in 10 schools. Staff visited Salford University for a one day introduction to the resource prior to the trials. Each of the schools was visited by one of the writers during the course of the trials. The schools kept a diary of any problems and also completed regular structured questionnaires on the progress of the work. The notebooks of the pupils provided a very useful source of feedback, often providing useful information on misconceptions and problems.

It is possible to summarise the outcome of the trials very simply. In those cases (the majority) where the teachers involved understood the basic philosophy of the resource the achievement of the pupils and the success of the trials was excellent. Some very good work was seen by the writers with pupils identifying a specific control requirement they wanted to address within an overall theme (usually suggested by the teacher). Where the teacher misunderstood the basic aims of the resource the result was chaos.

As an example of a successful trial, one school had chosen the theme of 'Controlling Children's Toys'. Different groups of pupils were observed to be making good use of the various parts of the resource to explore how to tackle specific ideas they had identified: how to control a monkey to appear to climb up a stick; how to control a roundabout; how to make a car reverse when it hit a barrier. The teacher advised the pupils on where they could get more information if they were 'stuck'.

As an example of problems with the resource, one trial school teacher gave the pupils copies of the data sheets and asked them to write notes about them at home.

## 6. Comments on the national curriculum revision proposals

The trials provided a wide range of evidence of effective approaches and pitfalls in introducing electronic systems to young people. It may be timely to comment further on the lessons of the trials and to relate them to the proposed revision of design and technology.

One important point concerns 'design and make tasks' suggested in the proposals for revision. These are clearly seen as substantial extended tasks. We have certainly found it helpful to include some major task of this kind (essentially the 'full' process of Figure 1). But we also have found it important to include shorter tasks (the 'fast' route of Figure 2) to develop breadth and progression. We strongly suspect that the same need for a variety of task lengths may well be equally important in other aspects of design and technology.

The following more detailed points also emerged:

- the pulse generator is very simple to understand (provided a systems approach is used) and was introduced successfully in the trials to 12 year olds. It is useful in all sorts of technology work and can be introduced far earlier than at national curriculum level 9 - as in the present proposals for the revision
- the latch, treated simply as a single input device with a push-button reset, is conceptually *simpler* than a two-input gate. In the proposals for the revision logic gates are introduced at level 7 but the latch is delayed to level 8
- even though a systems approach is explicit in the science orders and hinted at in some of the technology proposals, there is serious danger of a component-based approach being fostered by some of the proposed statements i.e. starting the process at the 'bottom of the hill' in Figure 1.
- it was found to be very important, particularly in work on fabrication, to ensure that pupils were encouraged to adopt a systematic approach to testing and fault finding. Where this was not done the problems of classroom management became serious. It was vital to emphasise quality control during manufacture by systematically checking that the output signal from a sub-system was correct before the next sub-system was built. The proposal in the revision only to introduce the use of test equipment at level 8 is dangerous. It would mean that pupils were unable to test and fault find circuits they have fabricated (introduced at level 6). This would inevitably produce massive pupil and teacher frustration.

- the present proposals make no mention of the use of a time delay or counter for control. These were introduced at 'level 2' of the resource. They proved both useful in helping pupils solve a wider range of problems and comprehensible to 12 year olds.

While these points may, with some justice, be regarded as of minor import in comparison with the broad issues of scope that presently are being addressed, they do point up an important concern. It is only by actually trying work in the *classroom* that some of the real problems emerge. For example, prior to the trials, the importance of systematically developing the ability of pupils to test their *own* systems was not recognised by the writers. In the view of the authors there is an important general point. The UK national curriculum suffers seriously from a lack of considered careful classroom trialling prior to its enactment as a statutory requirement. With the best will in the world no committee of experts can foresee all the problems, especially in a practical and creative subject area such as design and technology.

## 7. Conclusions

We consider that, provided teachers understand how to make effective use of it, the resource provides effective support, broadly consistent with the requirements of the proposed revision of the national curriculum for design and technology, for work with electronics.

But it is only effective in supporting teachers who do have a basic understanding. It was never intended as, and certainly did not prove to be in practice, a substitute for teacher expertise. The authors are convinced that the laudable goal of a design and technology curriculum for all pupils that looks towards the 21st century will only happen in reality when and if there are adequate opportunities for professional development of teachers.

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