Progression in electronics and communications technology

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Citation: MARTIN J. and BRANSON P., 2002. Progression in electronics and communications technology. Design & Technology Association International Research Conference, 12-14 April, pp. 139-144

Additional Information:

- This is a conference paper

Metadata Record: https://dspace.lboro.ac.uk/2134/3181

Publisher: © DATA

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Abstract

The paper is based on the Marconi Electronics and Communications Technology Project. The project aims to interest and educate a significantly larger number of young people in England and Wales in Electronics and Communications technology.

The Marconi ECT Project aims to support high quality work in schools up to GCSE level. The paper describes the criteria on which the project has selected content, and how that content has been organised at the levels of ‘Starter’ ‘Intermediate’ and ‘Advanced’.

In developing ideas for pupil practical activities, the approach that has been adopted is what we call a ‘layered’ approach. The intention is that, depending on experience and confidence, teachers need only look at ideas for pupil activities to the depth of ‘layer’ that they require.

A questionnaire-based survey of pupils in eight schools has been conducted to gauge their interest in a wide variety of possible projects.

Keywords
design and technology, electronics, communications, Marconi ECT Project

Introduction

This paper is based on the Marconi Electronics and Communications Technology (ECT) Project, which is supported by Marconi, DTI, DfES and TEP and managed by DATA. The project aims to interest and educate a significantly larger number of young people in England and Wales in electronics and communications technology.

The paper looks at:

- how, within the project, we have sought to systemise, in a progressive way, the knowledge, understanding and skills needed in work in ECT up to GCSE level
- our ideas for a set of progressive pupil activities at Key Stages 3 and 4 that will develop pupil capability in ECT
- surveys we have conducted into the views of pupils about possible activities

Knowledge, understanding and skills

The Marconi ECT Project aims to support high quality work in schools up to GCSE level. Given the wide scope of modern electronics, work up to GCSE level is necessarily highly selective in content.

The knowledge, understanding and skills have been organised under the following headings for the purpose of organising the web site (Marconi ECT, 2000), which forms a key part of the teacher support for the project. Of course, the organising headings are a matter of judgement. Certainly there is a great deal of overlap and interrelation between the various areas. Fortunately, in a web-based system, this can be allowed for by extensive cross-referencing hotlinks.

Systems design is used as a heading to provide a general overview of the key issues introduced at a given ‘level’ (see below).

Inputs and outputs introduces an increasing range of input sensors and output devices. Obviously, any electronic system must have input and output devices and so a key requirement of any ECT course that will enable young people to tackle a wide range of design issues, is to ensure that they understand the functions and can make use of a variety of input and output devices.
Software engineering is the heading used to introduce programmable control – using computers, interfaces and PIC microcontrollers. While the headings are not hierarchical, we have deliberately placed this section early in the list to emphasise to teachers its importance in modern electronics.

Systems building blocks and functions looks at more ‘traditional’ system-based design – gates, latches, counters etc. and gives teachers/pupils some understanding of their function.

Electronic communication systems will look at opportunities for using infra-red and radio communication in school design and technology. It will also look at familiar communication systems such as mobile phones and TV from both a technical and a social perspective.

Circuits and components focuses on unpacking the concepts and issues behind system building blocks. The approach taken in the project is to encourage pupils and teachers to think at a system block diagram level when considering suitable approaches to a design, but to be able to handle components and check circuits when proceeding to detailed work.

Manufacturing ECT systems covers the design and production of printed circuit boards and also looks at the organisation of batch production in schools. This section also includes extensive discussion of faultfinding, which we regard as very important for successful work on ECT.

ECT and the Internet will look at the technology underlying the Internet, its social and economic consequences and will also cover aspects of web page design.

An early policy decision was made to organise the material under these headings at the levels of ‘Starter’ (lower Key Stage 3), ‘Intermediate’ (high achieving Key Stage 3 or early Key Stage 4) and ‘Advanced’ (high achieving Key Stage 4 or early sixth form work). The question of course arises: What is a sensible sequence of progression in these areas? In seeking to address this we have used the following criteria:

- devices that are more familiar to teachers are covered earlier
- to simplify classroom management of practical work at Key Stage 3, systems that are simpler to faultfind are introduced earlier e.g. at ‘Starter’ level interfaces are introduced; PIC microcontrollers are left to the ‘Intermediate’ level.

Table 1 summarises the ways in which we have organised the material for the sections that have been completed.

Pupil activities
The Marconi ECT Project will only succeed if it leads to well-considered and interesting activities, which engage young people between the ages of 11 and 16 in understanding and developing electronic systems. We have sought to identify a range of possible projects that will be motivating and which will introduce pupils to the issues discussed above in a suitable sequence which will develop their capability in designing and using ECT systems.

One suggestion we have made is to develop, at Key Stage 3, two ‘contributions’ to work in ECT. One contribution would be from other focus material areas of design and technology (textiles, resistant materials, graphics and food) but where pre-manufactured electronic systems are used to enhance the final product. The second ‘contribution’ involves pupils actively engaging in designing and making with electronics.

There is a danger in a recipe approach to activities that can stifle teacher innovation, but there is also a need to suggest possible ideas to novice teachers. The approach that has been adopted is what we call a ‘layered’ approach to planning the ECT experience for pupils. The intention is that, depending on experience and confidence, teachers need only look at ideas for pupil activities to the depth of ‘layer’ that they require.

Layer 1 – the first planning layer suggests key concepts, knowledge areas and skills that are important at Key Stage 3 and Key Stage 4. Any scheme of work that motivates and engages pupils, enables them to achieve success and covers these areas is a good scheme!

Layer 2 – this planning layer offers suggestions on how, at each key stage, the key concepts, knowledge areas and skills could be subdivided into teaching units and suggests learning objectives for each unit. Some teachers may find that this level gives them enough ideas to devise their own teaching approaches.
Layer 3 – this planning layer includes, for each unit, a possible project outline that would meet the learning objectives. This layer provides enough information to get a less expert teacher going, but allows a considerable degree of flexibility in approach. This layer also gives a possible teaching sequence for each unit to support the complete beginner together with suggestions for pupil support materials.

Layer 4 – finally, there are accounts of how these units have been implemented in schools for aspects of both electronic products and ‘other material’ products, with teacher comments, examples of support materials and outcomes from pupils. These can be used not just by novice teachers but also for differentiation purposes and to provide ideas that teachers can adapt as required.

At the present stage, the authors and a group of colleagues (Martin Coleman, John Cook, Torben Steeg and Lee Tristam) have developed these ideas to a set of activities down as far as ‘Layer 3’. Our original
ideas are outlined as the items identified in Table 2 as – Key Stage 3: 1a, 1e, 1f and Key Stage 4: 1g, 1h, 1i, 1j (specific to Systems and Control GCSE), 1k and 1l. The items marked 1b, 1c and 1d are also on the web site but were not part of our original ideas for a progressive scheme of work.

**Pupil interest and motivation**

A key requirement is to engage young people in learning activities that they consider to be relevant and interesting. Two questionnaire-based surveys of pupils in 10 schools and four small single sex group interviews have been conducted to gauge their interest in possible projects which will be developed to cover the key concepts, knowledge areas and skills which we have identified above.

The results from the first questionnaire are shown in Table 2. The pupils were presented with the list of projects shown and asked to indicate if they thought the ideas were: boring, OK, interesting or very interesting.

Rather than present a confusing mass of detailed data, the responses have been ‘scored’ by rating boring = 0, OK = 1, interesting = 2 and very interesting = 3. In that way we have been able to arrive at an ‘average rating’ for each project idea, and that is shown by the bar charts. Also, again treating the ‘scores’ as real numbers, we have calculated the 95% confidence limits for the mean ‘scores’ of boys and girls combined for each project idea and these are also shown. Of course, this is not strictly valid statistically, because the ‘scores’ are not real measures of a numerical quantity. The approach has been adopted simply to make the mass of data accessible. There are a number of striking features.

Firstly, there is a marked discrepancy between the results from the boys and the girls. With one exception (1c) all the projects are less popular with girls. It is possible to use the $\chi^2$ test (without resorting to ‘scores’) to determine if these differences are statistically significant. To take the example of project 1a, there is only a probability of $4 \times 10^{-39}$ that the lower interest level of girls could be due to sampling statistics.

It is well established that far fewer girls opt for electronics at GCSE and our survey results are clearly consistent with this. The APU (1991) study into performance in design and technology showed that ‘the context effect on gender groups generally resulted in girls outperforming in the ‘people’ context and boys in the ‘industry’ context.’ This is consistent with our finding of a particularly marked gender split in the ‘industry’ project 1j and the fact that the only project that girls were more enthusiastic about than boys was 1c – which clearly relates to people.

The second noteworthy feature is that the general level of enthusiasm for our project ideas is disappointingly low. Most are around ‘OK’; few are regarded as ‘interesting’. It was therefore decided to explore possible alternative projects that would be more motivating to pupils but would still cover similar content.

First, four groups of six Year 9 pupils were interviewed to seek to understand more of pupils’ views and feelings. Points that emerged from these interviews were:

- electronics was unpopular with both boys and girls. They did not like the prescriptive nature of the work and contrasted it with freedom to try their own ideas in areas like food
- it was boring having to wait for equipment
- it was fiddly, ‘it’s easy to make a mistake soldering and then it’s difficult to put it right’
- you could burn yourself soldering
- they could not see much relevance of any area of design and technology (except for ‘cooking’ – ‘everyone needs to eat’) to their future lives or work
- they wanted to design ‘modern things’.

There was a striking similarity between the general points made in the interviews and the findings of Brochoka et al (2001). In the third and fourth interviews, possible ideas for projects were discussed and, using the pupils’ comments as a guide, a second questionnaire was developed. A key aim of this was to identify a better alternative to activity 1a, which was our planned first Key Stage 3 activity but which had a particularly low rating.

Alternative ideas evaluated included:

1. design and make a greeting card that plays a tune
2. a warning device that will show if your refrigerator or freezer is not storing food at a safe temperature
3. a soft toy that plays a tune if it is ‘hugged’ or warm or in the light.

All of these can address the same content as project 1a. The two most popular ideas were (i) and (iii) – both rated ‘Interesting’ by girls and ‘OK’ by boys. Our intention is to revise our ideas for the scheme of work and to incorporate the musical greeting card activity.

**Conclusions**

- we believe that we have developed a coherent scheme for progression in knowledge and skills for electronics in schools
- developing activities that are seen by pupils as
interesting and relevant and which address sound learning objectives is a demanding task

• we believe that the enthusiasm of the teacher is of great importance in motivating pupils and we know from discussions with teachers involved with the Marconi project that good presentation can make ‘boring’ activities interesting to pupils

• we would speculate that, while the interest ratings of some of our suggested activities are low, pupils in Year 9 are likely to rate may activities in a variety of subjects as ‘boring’

• special attention needs to be given to ensure that the contexts and approaches used are attractive to both girls and boys

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>95% confidence</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Find out about electronic sensors and make a moisture sensor to show when a house plant needs watering.</td>
<td><img src="image1.png" alt="Bar Chart" /></td>
<td><img src="image2.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1b</td>
<td>Design and make a key fob torch using a bright LED.</td>
<td><img src="image3.png" alt="Bar Chart" /></td>
<td><img src="image4.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1c</td>
<td>Design and make a greeting card that plays a tune.</td>
<td><img src="image5.png" alt="Bar Chart" /></td>
<td><img src="image6.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1d</td>
<td>Design and make ‘scary masks’ that make a wailing sound that changes when the light changes.</td>
<td><img src="image7.png" alt="Bar Chart" /></td>
<td><img src="image8.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1e</td>
<td>Use a computer to control a model of a film set or a theatre.</td>
<td><img src="image9.png" alt="Bar Chart" /></td>
<td><img src="image10.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1f</td>
<td>Find how electronics can be used in quiz shows. Build a timer for games you can play at home.</td>
<td><img src="image11.png" alt="Bar Chart" /></td>
<td><img src="image12.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1g</td>
<td>Find out about different electronic subsystems. Build a dice for games you can play at home.</td>
<td><img src="image13.png" alt="Bar Chart" /></td>
<td><img src="image14.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1h</td>
<td>Learn about different sensors and output devices and design and make an electronically controlled toy.</td>
<td><img src="image15.png" alt="Bar Chart" /></td>
<td><img src="image16.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1i</td>
<td>Design and make a flashing cycle light that is controlled by a microprocessor.</td>
<td><img src="image17.png" alt="Bar Chart" /></td>
<td><img src="image18.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1j</td>
<td>Use a computer to control models of equipment used in industry. Design and make models to do this, using a microprocessor.</td>
<td><img src="image19.png" alt="Bar Chart" /></td>
<td><img src="image20.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1k</td>
<td>Find out how electronics is used for counting and timing and model an electronic product for use in sport.</td>
<td><img src="image21.png" alt="Bar Chart" /></td>
<td><img src="image22.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1l</td>
<td>Design and build an electronic system for use in the Eden Project (environmentally controlled ‘biodomes’ for plants).</td>
<td><img src="image23.png" alt="Bar Chart" /></td>
<td><img src="image24.png" alt="Bar Chart" /></td>
</tr>
</tbody>
</table>

Table 2

Results from first questionnaire

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>95% confidence</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>88 boys</td>
<td>71 girls</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>Boring</th>
<th>OK</th>
<th>Interesting</th>
<th>Very interesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td><img src="image1.png" alt="Bar Chart" /></td>
<td><img src="image2.png" alt="Bar Chart" /></td>
<td><img src="image3.png" alt="Bar Chart" /></td>
<td><img src="image4.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1b</td>
<td><img src="image5.png" alt="Bar Chart" /></td>
<td><img src="image6.png" alt="Bar Chart" /></td>
<td><img src="image7.png" alt="Bar Chart" /></td>
<td><img src="image8.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1c</td>
<td><img src="image9.png" alt="Bar Chart" /></td>
<td><img src="image10.png" alt="Bar Chart" /></td>
<td><img src="image11.png" alt="Bar Chart" /></td>
<td><img src="image12.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1d</td>
<td><img src="image13.png" alt="Bar Chart" /></td>
<td><img src="image14.png" alt="Bar Chart" /></td>
<td><img src="image15.png" alt="Bar Chart" /></td>
<td><img src="image16.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1e</td>
<td><img src="image17.png" alt="Bar Chart" /></td>
<td><img src="image18.png" alt="Bar Chart" /></td>
<td><img src="image19.png" alt="Bar Chart" /></td>
<td><img src="image20.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1f</td>
<td><img src="image21.png" alt="Bar Chart" /></td>
<td><img src="image22.png" alt="Bar Chart" /></td>
<td><img src="image23.png" alt="Bar Chart" /></td>
<td><img src="image24.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1g</td>
<td><img src="image25.png" alt="Bar Chart" /></td>
<td><img src="image26.png" alt="Bar Chart" /></td>
<td><img src="image27.png" alt="Bar Chart" /></td>
<td><img src="image28.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1h</td>
<td><img src="image29.png" alt="Bar Chart" /></td>
<td><img src="image30.png" alt="Bar Chart" /></td>
<td><img src="image31.png" alt="Bar Chart" /></td>
<td><img src="image32.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1i</td>
<td><img src="image33.png" alt="Bar Chart" /></td>
<td><img src="image34.png" alt="Bar Chart" /></td>
<td><img src="image35.png" alt="Bar Chart" /></td>
<td><img src="image36.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1j</td>
<td><img src="image37.png" alt="Bar Chart" /></td>
<td><img src="image38.png" alt="Bar Chart" /></td>
<td><img src="image39.png" alt="Bar Chart" /></td>
<td><img src="image40.png" alt="Bar Chart" /></td>
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<tr>
<td>1k</td>
<td><img src="image41.png" alt="Bar Chart" /></td>
<td><img src="image42.png" alt="Bar Chart" /></td>
<td><img src="image43.png" alt="Bar Chart" /></td>
<td><img src="image44.png" alt="Bar Chart" /></td>
</tr>
<tr>
<td>1l</td>
<td><img src="image45.png" alt="Bar Chart" /></td>
<td><img src="image46.png" alt="Bar Chart" /></td>
<td><img src="image47.png" alt="Bar Chart" /></td>
<td><img src="image48.png" alt="Bar Chart" /></td>
</tr>
</tbody>
</table>
• the interest in doing ‘modern technology’ by pupils emphasises the importance of curriculum development and funding to allow pupils to work with resources they see as relevant to their lives and interests.

References
APU (1991) Assessment of Performance Unit, in The Assessment of Performance in Design and Technology, Schools Examinations and Assessment Council
Brochoka, K.Y., Baynes, K. and Smith, J.S. (2001) ‘Pupils’ views of school and popular culture, their opinions of design and technology at Key Stage 3 and their perception of the relevance of it for their future lives’, International Conference on Design and Technology Educational Research and Development (IDATER), Loughborough University