ECT: Electronics, Creativity and Technology?

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ECT: Electronics, Creativity and Technology?
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Abstract
There is small-scale research evidence (Spendlove, 2003) that Electronics and Communications Technology (ECT) is perceived by pupils as allowing little scope for creativity when compared with other focus areas of design and technology.

This paper reports a preliminary, small scale, investigation into the extent to which Spendlove’s findings are replicated in a study of schools where ECT has a substantial presence in the D&T Schemes of work and GCSE syllabuses.

Based on a combination of qualitative and quantitative data, coupled with scrutiny of schemes of work, the paper investigates the relationship between the teaching approaches adopted in ECT classes and the extent to which pupils feel they are able to engage creatively with the subject matter. In particular, we examine the extent to, and ways in, which the use of:
• a ‘components and circuits’ approach;
• a ‘systems’ approach;
• a programmable microcontroller (‘PIC’) based approach;
supports or hinders pupils’ perceptions of creativity.

The small sample doesn’t allow definitive conclusions to be drawn, but the data do indicate that, at least in some settings, pupils rate work in ECT as providing a great deal of opportunity for creativity and that the underlying ECT technology used is not the only factor affecting pupils’ creativity. This raises intriguing possibilities for further investigation.

Keywords: creativity, ECT, Electronics, Systems & Control, Systems, microcontroller, teaching approaches

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Background
This study was prompted by the surprising (to the authors at least) finding reported by Spendlove (2003) that, when asked to rate the opportunities for creativity in the various material areas of Design and Technology (D&T), no pupils considered the technical area known as ‘systems & control’ to be the most creative area. Both authors are aware of a great deal of work in schools in the area of ‘Electronics and Communication Technology’ (ECT) that they would consider to be highly creative, so this finding seemed to warrant further investigation.

Two broad explanations can be proposed for the views of the pupils surveyed by Spendlove: Firstly that the views that the surveyed pupils expressed on ‘creativity’ may be limited in some way, secondly that the electronics curriculum in the small sample of schools used might, indeed, have an uncreative or limited electronics curriculum.

For example, if the pupils had idiosyncratic or limited views of creativity this could limit their recognition of creative activity in a technical environment. Spendlove details the definitions of creativity that the surveyed pupils provided, summarising them as falling into three distinct groups, relating to cognitive activity (e.g. “being able to think of and produce things”), emotional expressive activity (e.g. “a form of expression using a combination of experience and ideas”) and ideational and imaginative activity (e.g. “inventive come up with new ideas”). Certainly this range of definitions provides an expression of creativity that we have sympathy for and could be used without difficulty to describe activity in ECT lessons. However it is interesting that Art and D&T are rated as ‘most creative subject’ by the vast majority (88 of 97); the remaining nine pupils selected six other subjects, including Music and

1 In the UK D&T is generally taught through the use of a range of materials including food, textiles, graphics, resistant materials (plastics, woods, & metals) and ‘systems & control’.
2 In the UK National Curriculum for D&T the phrase ‘systems and control’ is used to cover electrics and electronics, computer control, mechanical and pneumatic control and systems thinking. Increasingly the phrase ‘Electronics and Communication Technology’ (or ECT) is used for this area of the curriculum. In this paper the shorthand ECT will be used.
English which might have been expected to get very high ratings on such a question. It is possible that being canvassed for their opinions on creativity in the setting of a D&T lesson led pupils to give that subject unwarranted weight. If so, it is also possible that the specific D&T area that they were studying at the time of the survey also impacted on their responses.

Interestingly, when Davies et al (2004) asked primary PGCE students to select a ‘creative’ subject area to observe they came up with a very different pattern of creativity ratings, with Art & Design selected by 39% of students and English, the next most popular by 13%; D&T was selected by 7%.

Equally, it could be that many pupils had selected ECT as ‘second’ most creative and that this data remains unreported or that, as Spendlove notes, pupils had interpreted the question as being about the material areas that they personally favoured or were likely to choose for GCSE.

Finally, as noted above, it could simply be that the opportunities for creative ECT work in the sample of schools selected happened to be particularly low. Whatever the reasons for the attitudes expressed, a focused study of the potential for developing and expressing creativity within ECT was felt to be timely. This paper outlines some preliminary findings from this study.

Creativity, D&T and ECT
While the literature on creativity, both generally and within the subject of D&T, flourishes, we were able to find little that related specifically to ECT within D&T. What is agreed by researchers in the area is that defining creativity, either generally or in the context of D&T, is not a simple matter (e.g. Rutland 2002, Dakers 2004, Nicholl B 2004). Rutland (2002, 2003), through both study of the literature and interviews with professional designers and engineers, has developed a model in which three key sets of features of a setting interact with individuals to promote, or not, creativity. These features are those associated with the domain practices in a particular field of knowledge in which design is taking place, those associated with the process of designing and those associated with social and environmental factors that impinge on design.

Rutland concludes that:

“Each of the converging features of the model used for the analysis plays an important role in developing creativity. Lack of knowledge and skills in a domain, an unsound process or a poor social and physical environment will all affect, to some degree the ability of designers and pupils to be creative” (2002, p157)

Rutland (2004) has gone on to use the features of this model to analyse observation of pupils working in Key Stage 3 D&T in the material areas of both food and systems & control (using pneumatics and mechanisms rather than ECT). What she found in the systems & control work reinforces both the views of Spendlove’s pupils, the findings of OfSTED over a number of years (see OfSTED, 2004 for the most recent report) and Martin and Branson (2002); features such as limited opportunity for pupil originality, a focus on technical understanding, a set problem, and a narrow brief based around a competition led to there being little potential for pupils to demonstrate creativity, although other aspects of ECT related units were rated positively.

ECT teaching approaches
Teaching within ECT generally falls into one of three broad approaches:

a A ‘components and circuits’ approach. Here the focus is on understanding the workings of components and their actions in a circuit. Design and development work is at the level of individual components.

b A ‘systems’ approach. Here the focus is on ‘building block’ circuits and how they operate on circuit signals (Steeg 1995, 2000, 2003). Design and development is at the level of system circuit blocks.
A programmable microcontroller (‘PIC’) based approach. Here the focus is on defining the desired function of the circuit by programming this function into a microcontroller (a low cost ‘computer on a chip’) that is the core (‘process’) element of the circuit. Design and development is at the level of defining function in a graphical programming environment.

This is, in fact, a subset of a systems approach, the critical difference being that the ‘process’ elements of the circuit are in software rather than hardware.

The hypothesis underlying this study is that as the focus of work in ECT moves to a higher system level (from ‘a’ to ‘c’ above) the scope for pupil creativity will increase. Largely this is because as one moves to higher system levels the outcomes of design activity become both more robust and easier to adapt in the light of testing or new ideas, so teachers should have greater confidence in allowing pupils to follow their own ideas. In addition, higher system levels require smaller amounts of detailed technical information to be mastered before design work can start. Our hypothesis gains some support from Cooper (2000), who has made similar arguments for microcontroller technology being supportive of creative work (in that case with undergraduate teacher trainees).

In Rutland’s (2003) terms, as one moves to higher system levels the domain features of the task become much more accessible and the process features of the task become less technically demanding and allow thinking about what a product should do to rise above issues of how this might be achieved. As a result, the social and environmental features of the task also improve because the teacher will be freer in permitting or encouraging creative expression.

Research approach
To test this hypothesis we decided to elicit Key Stage 3 pupils’ views of activity they had recently completed in an ECT unit of work while at the same time gathering from their teachers detailed information about the unit. The data from the teachers would allow us to classify the teaching approach as discussed above. The pupils’ views would give us insight into the degree to which they felt the unit had encouraged a creative approach.

We wanted to avoid asking questions about creativity directly, partly so as not to prejudice the answers and partly because, as discussed earlier, we could not know how the respondents interpreted the word. Instead we looked for proxies for the concept of creativity that we could be fairly sure pupils would understand reasonably unambiguously. The proxy for creativity that we selected was ‘decision making’, which is an element of the process features of the task and which also relates closely to a key subject skill, that of designing, which necessarily includes as a precondition the opportunity for pupils to make decisions. Thus we would have data on two of Rutland’s feature sets (domain, based on the teaching approach and process, based on pupils’ responses) set firmly in the context of designing.

Data from teachers was collected during telephone or face-to-face interviews and supplemented by scheme of work information. Data from pupils was collected via a single-sided questionnaire with two sections. The first section provided prompts for short open-ended responses to questions about aspects of the ECT work just completed. A key question in this section asked pupils to describe the best idea of their own that they had included in the final product. The second section asked the pupils where they had been able to make their own decisions about the artefact they had designed and made, using a four-point Likert scale. Questions in this section included not only ‘obvious’ aspects of creativity such as aesthetics, but also technical aspects such as the materials and components used, the way the product worked and the tools, machinery and ICT that pupils had used. A final question in this section asked pupils how much they had enjoyed the unit of work.

Completion of the questionnaire was organised by the class’s D&T teacher and undertaken in the D&T lesson near the end of an ECT unit of work.

Results
The results reported here are preliminary and are based on responses from just six schools (including data from 131 pupils; 57 boys and 74 girls). In four of the schools, the ECT unit that pupils had finished just prior to completing the survey was based around the use of PICs (the dominant type of microcontroller in UK secondary schools): Pupils in School A had made an electronic die, those in School B had made a clock with an electronic novelty, those in School C a robot vending buggy for a public venue and the unit in School D was also PIC based. In the other two schools the units that pupils were surveyed on were all based on some form of ‘components
and circuits’ approach; in School E a timing device and in school F a simple robot buggy.

There were 12 questions in the second section of the questionnaire; 11 asking the degree to which pupils had been able to make their own decisions, and the final questions rating enjoyment of the project. The questions were:

During the project, how much were you able to make decisions about:
• What your final product did?
• How your product looked?
• How your product would be used?
• Who you were designing for?
• Where your product would be used?
• The materials you used?
• The sensors (e.g. light sensor, temperature sensor, microswitch…) you used?
• The output devices (e.g. bulb, LED, motor, buzzer…) you used?
• Other electronic components you used?
• The equipment (tools and machinery) that you used?
• The computer software and hardware that you used?
• How much did you enjoy doing this project?

Graph 1 shows the pattern of all the responses to all the questions; there is a fairly equal spread across all response options.

Graph 1: Total responses to all questions from all schools

Graph 2: Total responses to all questions from School A

Graph 3: Total responses to all questions from School B

Graph 4: Total responses to all questions from School C

Graph 5: Total responses to all questions from School D

Graph 6: Total responses to all questions from School E
These graphs are striking in their differences and lead us to ask what it is in the units of work and/or the approaches to teaching these units that causes pupils in some schools (with School A being an extreme case of this) to feel that they have had little opportunity to make decisions while those in others (for example School B) feel they have had much more.

Some indications of answers to this question become apparent when the data on responses to individual questions, shown in graphs 8 to 13 are scrutinised.

In School A it is clear that, despite the unit of work being PIC based, pupils felt that they had not been able to make decisions in any of the key technical areas relating to how the product operated, only in fairly narrowly defined non-electronic aspects of product design.

The responses from School C, where pupils had engaged in PIC based work, show a pattern that is, in many respects, similar to the response from School A; pupils perceived there to be relatively little opportunity for decision making in any of the technical areas. This school also has the lowest enjoyment rates of all the participating schools.
School D, also PIC based, shows a similar pattern to school B with pupils feeling they had been given some degree (rather lower than in School B) of decision making across a broad range of areas including some technical aspects. Enjoyment levels in the school are the highest of all schools in the survey.

In School E, where the technological focus was component based around a 555 timer chip, pupils felt strongly engaged in making design decisions about non-technical aspects of the product and also reported some opportunities for making technical decisions. Enjoyment levels were broadly similar to schools A and B.

Finally, school F, where pupils had been engaged in the design of a simple ‘robot’ buggy, shows a pattern of response that is similar to School B in non-technical decision making, but closer to school E, with a similar ‘components and circuits’ based unit of work, in the area of technical decision making.

Conclusions
As already noted, this is a preliminary study of a small number of schools. To properly test our hypothesis, or to draw any firm conclusions about the complex relationship between the ECT technologies used in a unit of work and the opportunities for pupils to engage creatively in product development, will have to wait for the study to be extended to a wider range of schools.

Despite their limitations, however, the data do raise some interesting issues. Firstly they indicate that the underlying ECT technology used is not the only, and probably not the most important, factor affecting the opportunity for pupils to be creative. For example, Schools A and B stand in stark contrast as having units of work based on essentially the same technology but allowing greatly differing amounts of decision making to be made by pupils. In Rutland’s (2002) terms, the domain features of the task are similar and the process (or design) features of the task seem to have been similarly dealt with but the data indicate that environmental features (which we might interpret here as the degree to which a teacher allows pupils to make their own design decisions) differ. Perhaps it is not always easy for teachers of ECT, with a long tradition of restricting technical decision making for very good pedagogic reasons, to adapt their pedagogies to new technologies that allow a greater range of technical decisions to be made.
In further support of the notion that the domain features are not the only critical aspect of creativity, Schools D and E have similar patterns of response despite the unit of work for one being based on PIC technology and the other on a component approach; the creativity opportunities provided for pupils are largely determined by the way in which the work has been structured by the teacher (an environmental feature). It is tempting to speculate that the teacher in School E, who is able to provide a wide range of decision making for pupils despite the limitations of a components based approach, would achieve a decision making spectrum more like that in School B if they had PIC or other systems technologies available to them.

In support of our hypothesis, of the six schools in the study, it is one of the schools (B) with a PIC based unit of work where the widest spread of decision making in technological (domain feature) aspects of the product is evident. This is suggestive and illustrates that it certainly is possible to structure work in the ECT area in such a way that pupils are given a substantial degree of design freedom in the design of the electronics hardware, the software and the product design.

Finally, it is encouraging to us that these preliminary data support the conclusion that teaching approach (an environmental feature) has a critical impact on the extent to which pupils are able to work creatively. This provides backing for the principle that a key feature of the large ECT teacher training programme that is underway in the UK should be a focus on not just technical understanding in ECT but also on appropriate pedagogies for ECT teaching.

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