

Questions concerning the introduction of micro-controller technology and creativity in D&T project work?

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Abstract

Our culture is underpinned by electronics technology and yet the number of students given the opportunity to study electronic technological concepts and apply these in design and make activities in secondary education is pitifully low. At the heart of the difficulties lie the inherent conceptual demands of electronics for both teachers and students.

This paper explores new approaches to electronics education with exciting opportunities for creative work through a case study of two students on the Primary BEd Teacher training course at The Nottingham Trent University engaged in their final year D&T projects. One student used conventional electronics and the other a micro-controller approach. Both projects demonstrated exceptional outcomes but the approaches showed marked differences, which shed light on the difficulties of using electronics for D&T project work and the significance of knowledge, which can either help or hinder metacognitive processes.

Educational context

Electronics education in the secondary curriculum has never been popular with less than 10% of secondary students take GCSE's in either Electronic Products or Control Systems. This paper explores some of the difficulties and opportunities through a case study of two students on the Primary BEd Teacher Training course at The Nottingham Trent University engaged in their final year D&T projects. One student used conventional electronics and the other a micro-controller approach. Both projects demonstrated exceptional outcomes but the

approaches showed marked differences, which shed light on the significance of knowledge, which can either help or hinder metacognitive processes.

The stimulus for this paper arose from my work with a team involved in pioneering new approaches to electronics education with exciting opportunities for creative work. It is relatively easy to relate the technical differences between the new and conventional approaches. However, understanding and trying to explain how a resource can contribute to greater creativity and self motivation rather than just relying on the novelty of a new approach raises a number of challenging questions:

- How can we recognise creativity in electronics-based D&T project work?
- How can IT and practical resources contribute to creative electronics?
- How can electronics knowledge contribute to metacognitive learning?

Research methodology

The methodology involved an action research case study where I acted as a customer and advisor to the students on behalf of the Women Into Science and Engineering (WISE) Vehicle Programme Unit during the period of their D&T project. The projects presented an ideal opportunity to observe electronics based work carried out within an holistic D&T process. The assessment required students to apply their understanding of materials, structures, mechanisms and control, gained over the four-year course, to develop an original, functional product of their choice. The students worked independently with tutorial support over a five-month period with an allocated two hours per week. Data was collected in the form of notes made during meetings and evidence from the project folios and product outcomes.

Project contexts

The students based their projects on updating the WISE Vehicle electronics workstations. The Millennium House idea involved a number of sensors and output systems, which could

be linked by logical process units to provide a variety of novel automatic control systems. Inputs included light, temperature, moisture and switches. The outputs were a barking dog, automatic curtains, washing line, lighting and heating.

The Talking Head workstation had a large head, which automatically emerged from behind a closed door and opened its eyes and mouth whilst making a welcoming animal sound.

Opportunities were provided to investigate the characteristics of various audio signal waveforms using an oscilloscope and to trigger mouth and eye movements in response to either speech or music.

Project analysis

How can we recognise creativity in electronics-based D&T project work?

The following definition of creativity has been adopted as a basis for analysing the work DfEE (1999):

‘Imaginative activity fashioned so as to produce outcomes that are both original and of value. (p.29)

The report adopts categories of originality, which are helpful to education.

Work may be original to:

- their own previous work
- to their peer group
- to anyone’s previous output.

The Millenium House and Talking Head may appear to be highly original. Most final year projects within the Primary BEd degree have been tackled on a restricted materials approach using wood or textiles to produce furniture or educational resources. However, closer

analysis revealed a number of creativity short-cuts. Both project ideas had evolved from previous WISE workstations encompassing similar technology and I had also discussed possible contexts with the students, including the ideas used in the final outcomes. The ideas generated were based largely on existing knowledge so where does creativity arise? Is it the glue, which binds existing knowledge elements in the synthesis of original outcomes or is it the acquisition of new knowledge? There is evidence to suggest that some students are discouraged from taking even low level risks due to perceived examination and assessment targets. Davies (2000)

How can IT and practical resources contribute to creative electronics?

Traditional electronics

The Millennium house workstation electronics were born from considerable pain on the part of the student. The following extract gives an insight to the difficulties

“I found using the different formats of drawing circuits difficult to write into Crocodile Clips and did not always use it. Some of my research was done using system boards. This was hampered by some of the boards being faulty. I investigated the logic gates I wanted to use in my model by using the WISE boards already available. This was more complex than I had originally thought and took several hours”.

The final project outcomes were very similar to the electronic boards used on the previous workstation but the apparent simplicity of the chosen logic board solutions disguised the hidden complexities introduced by the knowledge needed to realise the design. The student was faced with decisions involving a number of technical considerations including TTL / CMOS logic series, inverse NOR / NAND logic and analogue sensor amplification. This coupled with differences in circuit representation formats and faulty kits produced a negative learning experience, which made it difficult for the student to realise the electronic

educational opportunities for the workstation. Further supportive help produced a particular low point when the student sensed losing control of the process:

“The technicians from WISE used my plans and adapted the boards for my outputs and inputs. I felt I had lost ownership of my project at this point and I found it difficult to regain it as I had a missing link to the knowledge I needed”.

The student who developed the Talking Head workstation also underestimated the difficulty of progressing from modelling to making:

“I found what initially seemed to be a relatively small part of my project grew to being very complex. --- I needed to get my workboard electronics to talk to my ICON circuits. I also had limit switches with my mechanisms, which also needed to be linked with these circuits. This meant all the electronics were dependent on one another and it was very difficult to test them”.

The statement reflects the incremental difficulty in testing a number of interrelated systems. The process illustrates the pitfalls facing inexperienced students progressing from software simulations and system kits to circuit manufacture.

Micro-controller electronics

In making comparisons between the two projects the question of the relative abilities and experience of the two students cannot be ignored. However, the micro-controller resource offered some distinct advantages, which became obvious from the start.

The Talking Head student had successfully used a micro-controller approach for a previous project and was aware of its potential. This led to the idea for an ambitious automated

control sequence involving a door opening, a head emerging from behind the door and eyes and mouth moving in response to audio signals. This would have been demanding for conventional electronics but the micro-controller approach proved relatively straightforward to implement.

“I have used this program in a previous project although I have not used the ICON sequencer. I liked this function of the program and found as long as the program was written following a sequence of steps it was relatively simple”.

The value of the micro-controller approach came from the coherence of the design and manufacture process. System components are linked on-screen to form an icon-based program. Once the program has been written it can be tested immediately both on screen and using an external test board. Once proven a mouse click transfers the programme to a single micro-controller chip. Programs can contain the equivalent of 50+ conventional circuit components so there can be a considerable reduction in circuit assembly requirements and assembly errors. Creative options can be explored and tested and easily converted into a single cost effective chip.

Although the Millenium House student was aware of the possibility of using a micro-controller approach, an unsuccessful previous experience biased her against this route; *underlining the importance of success in educational experiences!* The ICON system would have been highly appropriate for her situation freeing time to give more considered thought to the educational aspects of the workstation electronics.

How can electronics knowledge contribute to metacognitive learning?

NACCCE (1999) defined metacognition as:

'Self-monitoring, reflection on performance and thinking about thinking form the basis of metacognition'.

The importance of critical evaluation in creative thinking was recognised with creativity seen as a form of learning particularly suited to the testing of complex conditions, skills essential for the twenty-first century. One self-evident outcome of D&T project work is the opportunity for critical thinking. When students set out to make something, which works the success or failure becomes obvious and can become a very powerful motivating force.

The Talking Head student commented:

"I enjoyed doing this project and found it extremely rewarding although at times I found it very difficult and challenging. I was disappointed that it did not work but due to its complexity this was to be expected".

It was apparent that both students were highly motivated by the task and explored knowledge areas beyond their existing experience and those of their peers. So what effect did the electronics dimension add to this work? Electronics was a significant element of both projects and contributed to the learning challenges and the originality of the outcomes. Electronics can add a stimulating and challenging dimension to D&T work and in its new educational form could be accessible to a wider range of students and teachers.

Conclusions

The study questions the nature of creativity within electronic-based D&T project work and suggests that although project outcomes may appear highly original they may be synthesised from knowledge gained from previous experience and a variety of sources. So what constitutes creativity in project work? Is it the glue used to join existing knowledge elements together in order to create something new. Is it related to new learning gained from the project experience?

D&T project work requires tools to enable students to turn vision into reality. Making can be very time consuming and modelling plays an important role in organising and testing ideas prior to making a product. The study suggests that electronics has proved a difficult medium for creative project work because of the detailed knowledge needed to make and test products. Component and system based software and kits can provide useful support but can still leave a wide gap between design and manufacture. Micro-controller chip technology can aid D&T project work by providing a more coherent and cost effective system for designing, testing and manufacture. What action is needed to stimulate the development of new technological tools, to evaluate them and to encourage their use in schools?

Project work can be highly effective in stimulating self-learning and electronics can add greater variety, versatility and relevance to this. What support is needed for both students and teachers to encourage creative approaches, which develop metacognition?

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