CREATIVE TEACHING IN DESIGN AND TECHNOLOGY

Review by Peter Stensel

INTRODUCTION

Creativity, innovation, problem-solving and hands-on experiences lie at the heart of Design and Technology, which is a relatively new subject in the secondary school curriculum in Singapore. In 1988 Design and Technology replaced the traditional subjects of woodwork and metalwork (which were seen as overtly prescribed and craft-based) with the aim of promoting creative design and problem-solving activities in school. In order to provide relevant experiences for pupils, it was regarded as essential that such activities also reflected the technological developments of the modern world (Linehan-Hill, 1994). With the Ministry of Education's recent requirement in Singapore that 30% of curriculum time should involve information technology by the year 2002, further developments in Design and Technology project work may well be necessary. One such development, identified by Cave (1995) involves the use of computers for controlling machinery, which provides tremendous scope for creative and dynamic projects in Design and Technology.

This article reviews the nature of problem-solving activities in Design and Technology, and describes an ongoing research project in a local secondary school, which is currently employing computer control to enhance its design activities.

DESIGN ACTIVITIES IN SECONDARY SCHOOLS

Design and Technology requires pupils to design and make a product using tools, materials and manufacturing processes which reflect the modern world. Project work is based around a problem known as a *design brief* , and the process of developing a solution to the problem, the *design process.* At ***lower secondary level*** Design and Technology is compulsory. At this level, all pupils work at the same problem (either individually or in groups) within certain constraints, to develop an outcome. The acronym PRIME (outlined in CDIS, 1993) is used to represent the design process and stands for

- Problem
- Research
- Ideas
- Making
- Evaluation

At upper secondary level, Design and Technology is optional. The design process is delineated in a more complex seven stage process (outlined in Lyons and Seow, 1996) which involves

- identifying the problem
- generating a design brief and specifications
- exploring ideas
- developing ideas
- production planning
- realisation (making the product)
- testing and evaluation

Wood, metal and plastics are still typically used as the construction materials for the products but the emphasis is now on the *design process* rather than the workmanship of the final product, and also on the use of such technologies as *mechanisms, structures* and *electronics*. For example, simple electric components such as motors, light bulbs or buzzers can be built into designs, allowing pupils to produce exciting dynamic products which involve movement, sound and light. Such designs move away from the static outcomes of the past, for example, small pieces of furniture, pencil holders or key tags, to more ambitious and innovative items, like security systems, guided vehicles and simple robots. Such projects were rarely undertaken in the past due to the problems associated with controlling the components, but computers can now facilitate the pupils' task.

INTEGRATING COMPUTERS INTO DESIGN AND TECHNOLOGY

Industrially, computers are used to control a wide range of products from robots and manufacturing equipment to stage lights and vending machines. These applications can be replicated in school on a less sophisticated scale using inexpensive components such as switches, light bulbs and motors. The components can be plugged into an interface box which, in turn, is plugged into and controlled by a computer.

The computer is programmed so that it knows which motor to switch on, for example, when a particular switch is pressed or a sensor activated. Such programming can involve pupils in complex problem-solving tasks. A common problem set for pupils is to design

Computer being used to control a robot.

a program to simulate the traffic light sequence of a pedestrian crossing. This can be extended to include the pedestrian 'figure' and the operating switch to control the figure's appearance when it's safe to cross.

Activities involving computer control are usually represented in terms of a ***system*** with an ***input*** stage, a ***processing*** stage and an ***output*** stage. In the pedestrian crossing example, the input stage would include a press switch to activate the system and the output stage would include three or more light bulbs and a buzzer to represent the traffic lights. A computer program determines the sequence of events and provides the processing stage.

RESEARCH IN COMPUTER CONTROL ACTIVITIES IN SCHOOLS

From his extensive studies of the use of computer control for educational outcomes in schools in the U.K., Bostock (1994) drew up a list of skills which result from using computers in this way. These include the following:

Conceptual Skills

- the ability to analyse a problem, breaking it into stages that represent separate tasks;
- the ability to design sequences and control structures that make up a control program;
- the ability to think and make decisions at a systems level of operation, i.e. input, process and output;

Practical Skills

- the ability to link together the separate parts of the system through a computer program;
- the ability to operate the control program effectively using the mouse and keyboard;
- the ability to adapt and develop all parts of the system so as to optimise its function;

Understanding

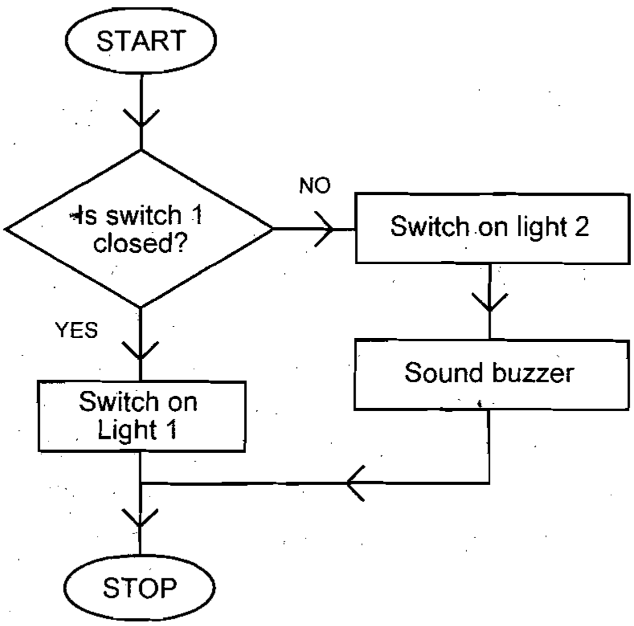
- an understanding of how software algorithms control the function of modern systems in our society;
- an understanding of how algorithms are built from software subsystems.

Choosing the appropriate software for computer control

The software chosen for programming the computer can be the key to success in control activities. Many software programs are available but, unless the software is easy to use, progression in this area is likely to be limited. From his research, Bostock (1994) suggests the following design criteria for a good programming medium:

- it should promote designing rather than coding;
- it should make use of skills that students already have from using drawing programs and spreadsheets;
- it should avoid the need to translate ideas to a lower level so that a computer can carry out the operations;
- it should use a medium that can communicate the algorithm as a form that is readily understood by others.

These criteria are satisfied in flowchart programming media such as *Logicator or Flowol* software in which pupils plot out programs rather like a drawing. The lower level functions are taken care of by the program. Such software avoids the need for pupils to learn a computer *language* and therefore allows faster progress in each activity.



A simple program for controlling 2 lights.

A LOCAL STUDY USING COMPUTER CONTROL

Hong Kah Secondary School, in Singapore, began using computers for control activities in 1995, with the aim of developing a relevant, forward looking curriculum for pupils which keeps them in touch with the latest technological advancements. With strong support from the school Principal, and an investment of S$70,000, part of one technology room was converted into a computer laboratory equipped with 15 sets of computers and 19 sets of system control kits. The approach taken by the Head of Department was to provide a progression of activities year by year which would enable pupils to use the medium in an informed way for their mainstream design projects. Three distinct stages of progression have emerged and are outlined below.

Stage One

The starting point for a Secondary One class involved the use of construction kit models such as the *FischerTechnik 3 storey lift*. This kit includes one motor (for moving the lift up and down), three light bulbs and six microswitches. The following problems were posed to pupils:

- *How can the lift be moved up or down to a given level?*
- *How can the lift be stopped at the correct position?*
- *What happens when more than one 'lift call' button is pressed?*
- *Where is the best 'home' position for the lift?, etc.*

Even at this elementary level there is more than one solution to the problems with no right or wrong answer. A further activity, suggested by Economatics (1995), entails pupils designing a lift system for an antiques warehouse in which access to the first and second floors is unrestricted but access to the top floor requires users to input a code number after they have pressed the call button.

Stage Two

Secondary Two pupils were set open-ended tasks such as to *design and make a product which interacts with the environment.* Again use is made of construction kits which are quick to assemble and which enable pupils to explore different mechanisms including gears and levers. Pupils investigate various sensors which can be built into the product to provide feedback from the environment. An example outcome would be a structure which moves in different directions according to varying light levels. Such activities allow for creative expression in terms of the appearance of the product, the movement which it produces and the flowchart which controls it.

Stage Three

Having attained competence in understanding the technology, pupils are then able to use it, where appropriate, in their mainstream design work. Bostock (1994) suggests a range of suitable project themes from fairgrounds to an advertising display. The latter might involve a rotating surface, flashing lights and sound. The display can even be programmed to respond in different ways when people approach the display to attract attention to the product. The important point here is that pupils are able to use control technology as a tool in realising solutions to design problems which, without the experience gained in stages one and two, would otherwise have been impossible.

Evaluation

Feedback from the teachers has been very positive to date, with pupils eager to use the technology. There has been an impetus to use more creative open-ended design briefs, and at the upper secondary level pupils are now using the technology in their examination projects. The initiative has been promoted through local publications such as *Design and Technology Education* and, as a result, other schools are beginning to realise the potential of computer control technology for Design and Technology.

IMPLICATIONS

1. ***Expose pupils to computer control activities in their design projects.***
   Computers are playing an increasingly important role in controlling devices in our society and they can provide creative and exciting opportunities for design and technology projects. Many teachers have pointed out the interest and motivation computer control activities generate in the pupils.

2. ***Select software which provides a flowchart approach to design.***
   Using software such as *Flowol or Logicator*, which allows programs to be developed as flowcharts, pupils spend more time designing and less time learning commands. Such software is available from local educational suppliers.

3. ***Plan a progression of activities which provide a range of experiences for pupils in using computers for control work.***

Well structured experiences in computer control are essential if the pupils are to be able to use the medium in an informed way for their design activities.

- *Begin with some structured tasks in Secondary One using construction kits such as the FischerTechnik 3 storey lift.*
- *In Secondary Two, give more open-ended tasks, which allow pupils to explore different components and mechanisms.*

By Upper Secondary levels, pupils should have attained competence in understanding the technology and be able to use it, where appropriate, in their mainstream design work.

SOURCES

Bostock, M. (1994). Progression within computer control in the National Curriculum. *Design and Technology Teaching*, 26 (2), 46-52.

Bostock, M. (1994). The scope of computer control within technology. *Design and Technology Teaching*, 26 (3), 20-24.

Cave, J. (1995). *Technology education briefing paper.* London, City Technology Colleges Trust Limited.

Curriculum Development Institute of Singapore (1993). *Technical studies for secondary 2: Design and construction.* Singapore. Longman.

Economatics (1995). *The FischerTechnik Kickstarts Book.* UK, Economatics (Education) Ltd.

Linehan-Hill, M. (1994). Control technology from the beginning. *Design and Technology Teaching*, 26 (3), 13-16.

Lyons, A. & Seow, A. (1996). *Design and Technology.* Singapore. Longman.

Technical Education Unit, Singapore (1997). *Design and Technology Education*, 9 (3), 2-3.