Developing links between computer aided learning and design and technology teaching

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Abstract
This paper discusses the potential for using Computer Aided Learning (CAL) as a means of developing design and technology capability. CAL is seen to be particularly attractive as a means of providing learning at the point of need, to simulate technological activity and to bring design contexts into the classroom. Although CAL has not always enjoyed a good reputation, recent developments in multimedia technology and 'flexible learning methods' suggest a clear role for its use in design and technology teaching. In order to make effective use of flexible learning materials which aim to provide alternative learning routes it is usual, if not necessary, to link some assessment of learner capability with the management and use of the learning materials. The paper suggests how computer based assessment of previous learning and computer aided learning materials would contribute towards developing design and technology teaching.
Finally, a case study of conventional diagnostic testing is described, followed by a proposed computer based model which aims to enhance the more conventional approach by:

determining a clearer indication of capability, suggesting a 'level' or 'model' of understanding when knowledge is applied to design situations.

providing immediate student feedback and suggested learning routes through 'flexible learning materials'.

providing collated student data to tutors for the purposes of informing their teaching, thus enabling the provision of appropriate teaching which will focus on real, rather than perceived, student needs.

Introduction

Recent consideration of design and technology in the national curriculum has highlighted the need to identify knowledge and skills which form core subject content, and to overtly develop pupil capability on a continuous basis. Whilst national curriculum documents which propose substantial subject content will be viewed by many teachers as supportive, the means by which this material will be taught is not immediately apparent. A succession of long, open-ended projects will not be appropriate and even a series of more efficient focused tasks or projects may not deliver all the requirements of national curriculum design and technology.
The NCC [1] suggest that at least three different teaching approaches should be employed :

Design and Make Tasks (DMTs)
Focused practical tasks
Disassembly and evaluation tasks

There is a need to provide a variety of activities which employ these approaches and to balance these activities in light of the nature of design and technology in schools. Recent draft proposals for new design and technology statutory orders seek to clarify the nature of the subject :

> "Design and technology capability requires pupils to combine their designing and making skills with knowledge and understanding, in order to design and make products" [2]

Doubtless, non-statutory guidance and other resource material will be published in order to provide much needed support in this area, but a basic dilemma remains - how to provide meaningful design and technology activities which encompass a broad range of designing and making skills alongside the development of specific knowledge and understanding?

The potential of CAL

Information technology (IT) is one resource which has great potential to support the development of design and technology capability. This potential was discussed in a recent paper to the DFE Consultation Conference on IT in D&T, and later published in Design and Technology Teaching. It concentrated predominantly on the emancipatory

use of IT, highlighting its use as a tool which enables pupils' project work to be completed more accurately and efficiently :

> "Consider the potential of IT in a number of specific categories of activity relating to design and technology: graphics, modelling, manufacture, control and information use." [3]

IT which seeks to support the development of specific capability may be described as computer aided learning (CAL) and the potential of IT in this role was also raised in our paper to the DFE conference. CAL systems typically simulate activities, instruct or reveal information, usually with a specific educational purpose in mind. Unfortunately, CAL has not always enjoyed a good reputation since it is often associated with the 'drill and skill' software applications used to assist rote learning. However, more recent developments in CAL have been able to take advantage of powerful computers and multimedia software, enabling pupils to browse through information and simulations, and to be directed to specific learning materials and activities. Such developments suggest that CAL may be a particularly appropriate means of supporting design and technology work. Examples of this support are:

- to bring real design situations and contexts into the classroom. Whilst there can be no substitute for the real experience provided by visits outside school, it is often impractical to take pupils into an industrial environment or other context which provides the air of realism required for design and technology teaching. Computer multimedia systems provide a viable alternative to the visit, supporting video descriptions with relevant data and interactive questioning.
- to simulate technological activity and so move more rapidly and effectively towards a design outcome. The computer has great capacity to simulate cause and effect, particularly when their interaction may be defined mathematically. The simulation of a change in structural load or the operation of an electronic logic circuit can be a powerful aid to understanding the design principles involved and their application to real products.
- to provide information or instruction at the point of need. The nature of individual project work is such that pupils may require skills or information which lie outside the range of that specified in the national curriculum. Traditionally, the acquisition of such information has been difficult to manage, but CAL applications can be used to support individual or small groups of pupils with specific project needs.

These examples lend themselves to implementation through the use of flexible learning methods. The use of flexible learning is by no means a recent innovation, although it is more often associated with the Open University's distance learning programmes and industrial training than the teaching and learning associated with national curriculum key stages 3 and 4. A good flexible learning package will identify with an individual learner, allowing them to work at a pace, and with a style, which is appropriate to their own needs and level of understanding. Typically, a wide range of information and activities are provided, and pupils use a sub-set of these to follow an individual learning route. This route is usually informed by pupil self-assessment or a teacher's formative assessment. The NCET recently published a guide to the potential of IT which reflects the benefits of more flexible approaches :

> "IT has the flexibility to meet the individual needs and abilities of each student...not everyone learns in the same way or at the same pace. Good teachers have always sought ways of presenting teaching material in different ways for different pupils, but this is not always easy to do. Information technology can help"

and

> "IT gives students immediate access to richer source materials...students are not limited to the resources within their physical reach...information skills like skimming and scanning and the use of key words develop naturally." [4]

Two key teaching requirements of national curriculum technology would benefit from the use of CAL support:

(a) A need to provide information, knowledge and understanding beyond the core content specified in programmes of study. 'Design and make tasks' which truly reflect the real nature of design and technology will require pupils to apply knowledge and understanding which is specific to their own design work. Often this will fall outside the work covered in more focused tasks and will not be relevant to the rest of the class. CAL is able to support the independent research and learning required, minimising the direct teacher support which might usually be identified with such tasks.

(b) Where knowledge and understanding which is relevant to core subject content has been identified, the needs of individual learners may be accommodated through the use of CAL which:

> "can work at a speed suited to the student's

> needs, rather than at a common pace....can provide different entry and exit points ... can give immediate positive feedback ..." [5]

Many teachers of design and technology will identify with the potential of CAL in these situations, but in order for CAL to be effective there is a need to correctly manage the learning, and for pupils to take real responsibility for their own learning. These issues lie at the heart of both flexible learning and educational computing applications, and are discussed in some detail by Underwood who concludes:

> "The questions to be resolved then, are how do we select the path to take when the computer offers a range of instructional and learning strategies, and, once we have selected the pathway, what do we do to ensure that our educational goals are reached?" [6]

Implementing CAL in design and technology

In an attempt to improve the teaching of Foundation Technology to our year 1 Industrial Design and Technology students I was recently involved with the development of a flexible learning package about energy. This development was described in a paper presented at IDATER 93[7] and included some limited diagnostic testing exercises. These self-assessment exercises provided students with a measure of their own understanding, helping them to select appropriate laboratory activities and exercises for subsequent learning. This approach was later extended to include diagnostic testing of mathematical, electronic and mechanical knowledge and understanding. Although objective data is not yet available, there is every indication that this approach was beneficial to a student cohort with a wide range of educational backgrounds. We were able to provide support tutorials and focus teaching activities to be of particular benefit to specific groups of students. The inclusion of diagnostic testing and self assessment in CAL applications will clearly aid the management of such resources, identifying appropriate teaching materials and activities for individual learning needs.

However, there is a need to employ diagnostic testing which determines a pupil's understanding when it is applied to certain design situations. The previous testing and assessment indicated what students knew about maths, electronics or mechanics. By asking them to apply their knowledge and understanding to design situations, a formative assessment which more closely reflects the nature of design and technology will be achieved. The use of CAL techniques which rapidly provide design context, simulate technological outcomes and objectively evaluate pupil capability will allow this approach to be implemented effectively. It suggests a model which uses computer based assessment of previous knowledge and understanding to manage and inform the use of computer aided learning materials. Particular requirements would be to:

- identify a level or model of understanding in the context of design activity;
- provide immediate student feedback from self assessment and suggest appropriate learning routes/materials;
- provide relevant student data about assessment and diagnosis in a collated form for use by tutors.

Trial materials will shortly be available which are concerned with the knowledge and understanding required to design electronic products. The computer provides design background to a range of familiar products and poses a series of questions and/or opportunities to explore the context in greater depth. By analysing student interaction, the computer is able to instantly provide a profile of their understanding and suggest sources of appropriate information and learning resources.

For example, discussing how the temperature of boiling water may be detected and how control may be applied to the heater in an electric kettle so that energy may be saved, might be an appropriate product context. The distinction between understanding control systems in general and the needs of this specific temperature control requirement is easily identified through simple written tests, but the computer can provide students with help and information at different levels or in different ways, and allow them to simulate or calculate their own design proposals. The amount of help provided, and the type of calculations employed are indicators which provide a more detailed picture of a student's capability. They can be used by students to help them determine an appropriate course of self study or by tutors who wish to focus their teaching on the needs of a particular group of students.

This approach towards diagnostic testing and assessment may go beyond the tools and tests used in most conventional flexible learning packages, but in no way reflects the level of knowledge which teachers usually have about their pupils' ability and experience. The intention is that such a system would, in the first instance, enhance or streamline the teacher's own assessment and suggested

resources - particularly with a new group of pupils or students. It is hoped that key indicators will emerge which allow the computer analysis of diagnostic tests and assessment to directly link the learner with appropriate teaching materials and information. Such a system would be a powerful tool, well able to address key teaching issues concerned with the development of design and technology capability.

References

1 NCC, Technology POS and ATs: Recommendations of the National Curriculum Council, 1993

2 SCAA, Design and Technology in the National Curriculum : Draft Proposals, 1994

3 Hodgson, A.R. et al, Information Technology in Design and Technology : A discussion paper, in Design and Technology Teaching, Vol. 26, No. 2

4 NCET, Information Technology Works, 1994

5 NCET, Information Technology Works, 1994,

6 Underwood, J.D.M and Underwood, G. Computers and Learning, Blackie, 1990, p21