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Introducing CAD/CAM into Primary Schools
Part 1 of a case study – Developing the Curriculum

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Abstract

This paper describes the first part of a small case study in which a secondary school works with three partner primary schools to develop computer assisted design and computer assisted manufacture (CAD/CAM) expertise in primary school children in Years 2, 4 and 5. Three secondary school teachers developed units of work incorporating CAD/CAM, taught these units to small groups of primary school children who will then act as peer mentors to the rest of the pupils in their class when the entire class is taught the unit. The nature of the work produced by these small groups is discussed in terms of the design decisions made by the pupils.

Key Words

computer assisted design (CAD), computer assisted manufacture (CAM), primary, designing, making, design & technology

Introduction

This paper will describe the preliminary activities undertaken by a secondary school and three partner primary schools to develop computer assisted design and computer assisted manufacture (CAD/CAM) expertise in primary school children in Years 2, 4 and 5. The following questions drove the overall study.

1. To what extent can primary school children engage with CAD/CAM?
2. What is the impact of peer – peer mentoring by primary children on this engagement?
3. What sort of design decisions do primary children make when using CAD/CAM?
4. How do these design decisions compare with those made by primary children using traditional approaches to designing and making?

This paper is divided into five parts. The first part is a short discussion of the background to the project. Second is a description of developments so far. Third, is a statement of next steps. The fourth part discusses the issues arising in terms

of the research questions driving the study. The final part presents a short conclusion. The impact of peer-peer mentoring will not be discussed in this paper as research is still to be conducted and therefore will be completed at a later date, with the possiblity of a further publication.

Some background

Computer assisted design (CAD) and computer assisted manufacture (CAM) are now an established part of the statutory requirements for design & technology in secondary schools (Qualifications and Curriculum Authority, 2007). Recently there has been evidence that this has had a significant impact on the nature of designing and making at GCSE and A level (Fraser and Hodgson, 2006, 2007). There is considerable support for the use of CAD/CAM in secondary schools through the Design and Technology Association's CAD/CAM in Schools programme which has been in existence since 1999 (www.cadinschools.org/page.php?m=47).

The situation in primary schools is different although there is a statutory requirement to use ICT based resources for generating ideas and a range of equipment including ICT (for example 'drawing software or CAD software and printer) (http://curriculum.qca.org.uk/key-stages-1-and-2/subjects/design-and-technology/keystage2/index.aspx). Benson (2002) noted that of a sample of pupils interviewed only 1% said that they had used CAD in any form although all were enthusiastic to try. More recently Rutland et al (2006) reported that in a survey of primary ITE students from five HEIs the perceptions of students indicated that there was 36% of schools with access to ICT to support design & technology. To provide guidance in the use of CAD/CAM in primary schools the National Association of Advisers and Inspectors in Design and Technology published CAD it! CAM it! A guide for teachers (Cater, 2006) but there has been no national scheme to provide in-service training for primary school teachers in CAD/CAM.

The TECHLINK project, although local in nature reaching schools in the South West of England, is a significant primary school CAD/CAM initiative (www.techlinkinschools.com). It has been developed by the Medlock Charitable Trust and Denford Education Support Services alongside Hayesfield School in Bath. Hayesfield is a very popular girl's school with a co-educational sixth form. The school is in its second phase as a specialist technology college. There are approximately 1,200 on roll and the school serves socio-economically diverse communities across the city of Bath (Hayesfield School Technology College Ofsted Report 2006). The secondary school has developed the courseware in association with its primary school cluster over the last two years. This initially involved the use of Master Robo software however, this has been extended to incorporate the use of Techsoft 2D software.

A key feature of design and technology is the extent to which it engages pupils in making design decisions. Barlex (2007) has suggested that these design decisions include technical (how their design will work), aesthetic (what their design will look like) constructional (how their design will be made) and marketing (who the design is for, where it will be used). Mettas, Thorsteinsson and Norman (2007) conclude from a study of three national curricula (Cyprus, England and Iceland) that although there are many opportunities for decision making in design and technology classes in practice some teachers believe this is not feasible and that children rarely 'set appropriate criteria to support their design decisions' and that associated formal training in decision making techniques might 'improve the quality of children's decisions during design activities' (p.68). Barlex (2004) has reported on the wide range of design decisions that pupils are encouraged to make using Nuffield Primary Solutions units. Given the comments of Mettas et al it will be particularly important to ensure that with the introduction of CAD/CAM into the Nuffield units that this approach is not compromised.

Peer – peer mentoring has been used successfully for a wide range of educational and professional training activities. For example Dennison (2000) reports on a 'Big Buddies' programme which was successful in preventing high school dropout and increasing young people's interest in taking part in voluntary organisations. Mascall (in Elliott 2002) has written about the use of this type of mentoring as a successful strategy in tackling bullying in schools. It is not surprising that peer – peer mentoring has been used successfully. Vygotsky's conceptions of cognitive development have placed major emphasis on the supportive and cooperative role of the child's partner (Schaffer in Daniels 1996).

The second part of the study will explore the impact of peer – peer mentoring on the teaching and learning of CAD/CAM in the primary classroom and will be the subject of a later publication.

Developments So Far

In March 2007 David Barlex of the Nuffield Design & Technology project met with David Barnard, the manager of the TECHLINK project. Through discussion they agreed that collaboration between the two projects would be of mutual benefit. The aim of the collaboration would be to modernize some Nuffield Primary Solutions units (Barlex 2001) by developing a CAD/CAM component within the units, to pilot these adapted units with primary schools involved in the TECHLINK project and then after making any necessary revisions make these units available free of charge from both the TECHLINK and Nuffield Design & Technology websites. The benefit for the TECHLINK project would be the development of new curriculum materials within a tried and tested framework and the benefit for the Nuffield project would be the extended useful life of the existing, now adapted, units.

In January 2008 David Barlex met with Ian Taylor, deputy head teacher of Hayesfield School, and through discussion with three secondary school teachers from Hayesfield who had already worked with partner primary schools in the TECHLINK project they identified the primary solutions units that would be modernized to include CAD/CAM. These units were:
What should be stuck to your fridge? In this unit pupils are required to design and make a fridge magnet that is made of layers and is part of a set that will appeal to young children. This unit would be taught to Year 2 pupils.
How will you store your favourite things? In this unit pupils are required to design and make a container to act as a treasure chest for favourite small items. This unit would be taught to Year 4 pupils.
How fast should your buggy be? In this unit pupils are required to design and make a controllable, battery-powered toy vehicle for an identified user. This unit would be taught to Year 5 pupils.

The teachers decided to use Techsoft 2D software in combination with the Craft ROBO cutter plotter (http://www.signmaster.co.uk/craftrobo/CRAFTROBO.htm).

During March and April each of these secondary school teachers then taught their chosen unit to a small number of primary school pupils from each of the three target schools so that the pupils could become experts and provide advice and guidance to their peers. Later in the year the entire class from each school would visit the secondary school with their class teacher and

together with the secondary school teacher and the help of the pupil experts tackle the modernized primary solutions unit. The teacher working with *What should be stuck to your fridge?* has created four lessons and reported that pupils had worked well with the design software, but had found it difficult to imagine a 2D drawing built up in layers. The designs for the fridge magnets have been linked to a cross curricular project on Native American Indians, so pupils created designs of wigwams and buffaloes. The screen showing the component parts of a wigwam (in Figure 1) illustrates three layers, which when assembled will have a top layer the entrance, a middle layer the wigwam fabric a bottom layer the sticks supporting the fabric. The examples of pupils' work (in Figure 2) show that this was an option pursued by the majority. The teacher noted that the pupils were less comfortable with the cutting machine hardware.
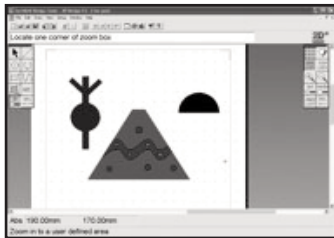

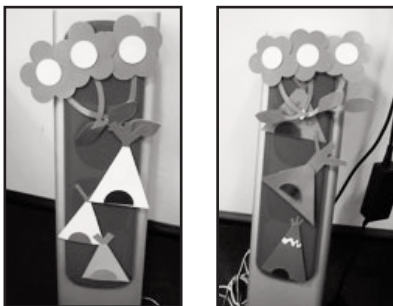*Figure 1: Screen shot showing layer parts for a wigwam*

Figure 2: Wigwam Fridge Magnets

The teacher working with How will you store your favourite things? has created seven one hour lessons based on nets. He reported that it was difficult to make some of the nets in the Nuffield unit using a computer as this required the calculation of angles. He has therefore focussed the lessons on a cube, making a box with a lid as shown in Figure 3.
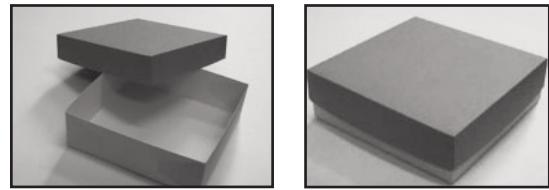

Figure 3: The box plus lid developed from a cube starting point

He was able to engage the pupils with improving the appeal of the box by creating a design that was then cut out as shown in Figure 4.
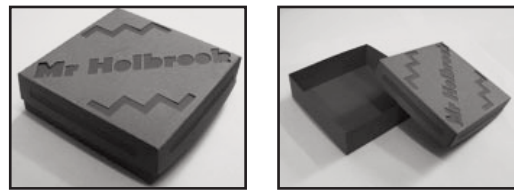

Figure 4: A box with decorated lid

He was able to involve pupils in the development of boxes separated into compartments as shown in Figure 5.
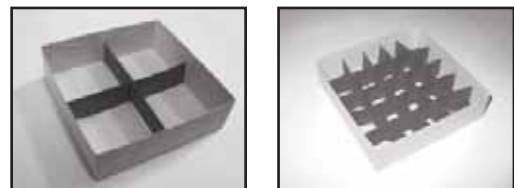

Figure 5: A box with compartments

The teacher working with *How fast should your buggy be?* has produced five one hour lessons for this project. He has worked with four Gifted and Talented Year 5 pupils and has been impressed with how independent the pupils are. He has developed some very interesting construction techniques involving square section tubes which are easy to make using the Robocraft cutter plotter as shown in Figure 6.

Figure 6: Construction techniques for buggy design

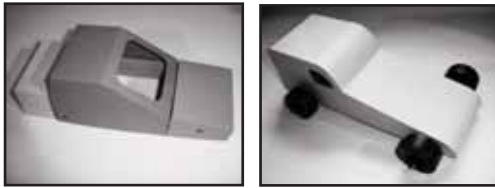At the moment he has produced two possible body shells as shown in Figure 7.

Figure 7: Possible body shells

Next steps

The visits of the whole classes are scheduled to take place in June, and will be reported in a later paper. These sessions will be video recorded. One of the authors will visit these sessions, make observations, take photographs of work in progress and finished work and interview the pupils and their class teacher to gain their views on the activity and the peer – peer mentoring. Once this data is available the three primary solutions units will be revised accordingly and posted on the Nuffield and TECHLINK websites.

Discussion

The place of CAD/CAM in secondary school design and technology does not go uncontested. Banks and Owen-Jackson (2007) note that it is important to "discuss the position and purpose of CAD/CAM in design and technology and the balance between 'high tech' and 'low tech' skills, knowledge and understanding. Chalkley (1999) gives a stern warning through her experiences with a small group of Year 5 children.

> It would seem that experiential work using concrete materials provided this group of children with sufficient confidence to explore possible solutions. Discussion also, enabled them to find a way forward. But the introduction of ICT at this group's stage of design development, seemed beyond their capabilities both practically and conceptually.
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The work of the teachers and children so far in this small study indicates that the developments in software and hardware since 1999 have made designing on screen more accessible and potentially successful. Hence in terms of the first research question "To what extent can primary school children engage with CAD/CAM?" the answer appears to be in the positive. All the pupils involved in the study were able to use the CAD software and to a lesser extent the CAM hardware.

But it is important not to be complacent and to consider the responses of the pupils in terms of two further research

questions "What sort of design decisions do primary children make when using CAD/CAM?" and "How do these design decisions compare with those made by primary children using traditional approaches to designing and making?" In the fridge magnet work the wigwams look similar. It will be interesting to see if the inclusion of CAD/CAM supported by peer – peer mentoring will give rise to a wider range of products e.g. different sizes and shapes of wigwam, feathered head dress bonnets, totem poles etc. It may be that initially CAD/CAM increases the quality of the manufacture but limits the variation in design. The limitation of the software to deal with different shaped boxes in the container work is a similar potential cause for concern although this is to some extent alleviated by the opportunity to decorate the exterior in ways that are unique to individual pupils. Also the opportunity to divide the container into compartments presents opportunities for individual design decisions. An interesting extension of the decoration might be to ask the pupils to decorate the exterior such that the decoration hints at what the box might contain. Hence if it was for my favourite four marbles I might decorate the lid with 'cut out' overlapping circles revealing a shiny coloured paper reminiscent of marbles. It will be important for pupils designing buggies to be able to make genuine design decisions concerning the nature of the chassis and the body shell.

Hamilton (2005) describes the technical tinkering crucial to the problem solving that accompanies making design decisions in design and technology. A pupil is having problems with undue lateral movement in a pivoted beam. The description of the pupil's attempt to solve the problem is revealing.

> Matthew went on to glue a piece of card over the hole that he had made and then reinserted the pivot rod. This did not work to his pleasing but after some perseverance and struggle he glued a part lollipop stick to each side of the beam and this worked when he inserted the pivot. Matthew was really pleased he had solved the problem and with teacher support, he had remained open-minded and persistent until he was happy with the outcome.
>
> (p.75)

Matthew's struggle with lateral movement is reminiscent of Chalkley's concern (1999) for the need of "experiential work using concrete materials".

Hamilton (2007) goes further in exploring the mental activity that is required for designing. In describing pupils response to a story in which a child was in danger of being killed by a runaway train he reports.

The driving force was the mental model pupils had constructed in their mind's eye at the outset of the story. In designing solutions that worked the pupils constructing other mental models as they reasoned and developed further solutions to the problems they had identified. The video clips showed the pupils engaged in the process of visualising, (standing back and musing over a problem), communicating (talking with or without sketches but always with reference to the model) and acting (interacting with objects and modelling possibilities). Permitting time and space for this to happen was essential for a successful and creative outcome.

(p.33)

We have to ask "what is in the mind's eye of the pupils designing the fridge magnet, the container or the buggy? It may be that the tasks chosen for modernisation through the introduction of CAD/CAM are insufficiently open to enable pupils to respond in the way described above. In which case we would argue that it is important to use such tasks as steppingstones towards pupils being able to operate fluently with CAD/CAM as a tool that genuinely empowers them in designerly thinking.

At the time of writing the data to answer the question "What is the impact of peer – peer mentoring by primary children on this engagement?" is still to be collected. A consideration of this data and the light this throws on the issues identified above will be the subject of a later paper. It is hoped that the video record will capture the interactions between the skilled pupils and their fellow peers, allowing analysis of the transcript to reveal the full extent and means by which this communication has assisted all parties, showing just how much the non-skilled pupils have had their work enhanced by their skilled counterparts.

Conclusion

In recent years it has been easier for primary pupils to engage with CAD/CAM through the software and hardware that are now available. When the pupils were given the opportunity to express themselves freely with their designs, it was found that due to their lack of experience in making design decisions their finished products appeared to be limited. This may prove to be a false concern when the pupils with the newly acquired skills have the opportunity to peer mentor their fellow class mates as they learn how to use CAD/CAM in the pursuit of simple designing and making assignments. The presence of the class teacher might also encourage and enable pupils to develop more diverse solutions.

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