DfEE/DATA CAD/CAM in Schools Initiative The Designing and Making Revolution in Design and Technology Education

Abstract

This paper sets out the context for the CAD/CAM in Schools Initiative and the remarkable rate of implementation that has taken place in our schools. It sets out the research findings after 20 months of the programme based on analysis of work in the pilot schools and from other schools that are participating in the scheme. From this it draws out the achievements and the challenges that schools are now experiencing, setting out the new thinking that is emerging and a number of ways in which the programme is now trying to consolidate its work. The paper goes on to draw out some of the major issues that are beginning to emerge.

Introduction

There have been many curriculum development initiatives in design and technology over the last 30 years, some have addressed the whole rationale of the subject, some have developed thinking and understanding, some have produced a range of low cost equipment or curriculum materials. The impact over time of many of these initiatives can be measured by their influence and impact on practice in our schools. The CAD/CAM in Schools Initiative is having more instantaneous impact than perhaps any other design and technology initiative and it could be a greater impact than any single IT or ICT programme in the curriculum. This in many schools is the quiet revolution in design and technology. It is motivating teachers by giving them the tools to be able to teach designing with powerful tools that industry uses and it is giving students tools that allow them to be creative, freeing them from time consuming drawing and exciting them with tools which enable complex activities to be carried out. Michael Wills, the Minister for Learning and Technology, speaking at the first ever CAD/CAM in schools conference at Warwick University in March 2001 stated:

> 'The impact of this programme cannot be overestimated. It gives high quality software to our schools in a structured manner. We have the right ingredients – it's part of the National Curriculum, powerful software, accredited training, school targets for implementation, a well managed scheme with excellent links to industry, but most important a coherent programme well received by schools, teachers and students. It is a major success story by whatever measure you wish to apply.'

The CAD/CAM in schools conference, held in the world renowned International Manufacturing Centre at Warwick University in March 2001, was the first ever residential conference held anywhere in the world to discuss, celebrate and identify ways forward in this emerging area of work. The conference was fully booked and attended by more than 220 delegates, the impact of the initiative was clear to see by the expert way many teachers were working in this area and the enthusiasm and commitment of the teachers. A wide range of issues have emerged from the conference seminars and discussion groups, which the Government and profession will need to address. At the conference, PTC (the company that provides Pro/DESKTOP software) announced that DATA would be allowed to make available the software to any individual school, anywhere in the world. Full details are available on the CAD/CAM in Schools web site www.cadinschools.org.

The CAD/CAM in Schools Initiative has 55 pilot schools with targets set as part of their competitive bid for resources. These schools have a variety of equipment and software, with 35 schools having 10 laptops and the other 20 having one laptop. The software covers CAD/CAM in electronics and product design. The schools were all given Pro/DESKTOP software, but unlike other schools, the pilot schools did not have to undertake training in the software. A series of hubs were initially established in 2000. The full nature of the scheme and how software is released was set out in the *Journal of Design and Technology Education* Volume 5 Number 2 (2000).

The first report on the pilot schools concluded that training to use Pro/DESKTOP was essential; some schools had found phasing in the equipment difficult, the problems with the laptops were considerable – thus using the extended warranty obtained by DATA and finding strategies for using the laptops and software at home proved challenging. In addition, schools need to consider developing expert groups of students and finding methods of accessing more computers and machine tools for manufacturing. Schools with changes of staff also experienced difficulties.

Figure 1: Michael Wills MP speaking at the first DATA CAD/CAM Conference.

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Chief Executive, DATA and Director of the CAD/CAM in Schools Initiative

CURRICULUM

Figure 2: Students' work exhibition at the conference.

The pilot schools are now a small part of the programme because of the pace of implementation. The following catalogue shows the rapid rate of progress of Pro/DESKTOP:

- September 1999 – pilot schools sent software without a requirement to train
- September 1999 – first accredited trainers trained at the University of Warwick
- October 1999 – accredited trainers begin work
- End of May 2000 – 1000 Pro/DESKTOP software licences released
- October 2000 – accredited trainers for Wales are trained
- March 2001 – 65% of Welsh Schools have accredited teacher in Pro/DESKTOP
- May 2001 – 3,400 teachers registered in Pro/DESKTOP, 400 plus trainee teachers and 165 accredited trainers in Pro/DESKTOP.

Delcam donated ArtCAM in December 1999 and training of accredited trainers began in the spring term 2000. The momentum gained by Pro/DESKTOP has somewhat overshadowed this excellent software; however, interest is growing and with new resources being developed this software will soon have greater impact.

Early findings from the CAD/CAM in Schools Initiative

These findings come from detailed evaluation of the pilot schools and extensive visits to a range of schools implementing the CAD/ CAM in Schools Initiative. There is no doubt that the implementation of CAD/CAM in the programmes of study for the National Curriculum in design and technology has been a major factor in moving this area of work forward. It has also been noticeable that where LEA advisers have been actively involved then progress has been more rapid.

Since the first reports, most pilot schools have now trained at least one member of staff in Pro/DESKTOP, some have accessed ArtCAM and a number have sought training in the use of some of the electronics software. The impact in some pilot schools has been highly significant, in others progress has been more measured; only three schools showed cause for concern in terms of their targets and these had all suffered from staffing problems. The level of interest and support from head teachers was generally good, but in some cases there was evidence of staff being disappointed by their lack of support from senior staff. The major weakness was the school's failure to add to the resources to make it meaningful in terms of exploiting the full potential of the software. It is clear that where schools did not consider they needed training, impact has been less effective in most cases. This clearly shows that 'free' software with no strings or structure such as accreditation and registration is less likely to succeed. This is in line with the experience with the CBI Manufacturing by Design CAD project.

The turnover of staff in pilot schools has been high; 7 out of 55 schools have had a change of staff, and in addition there has been serious staff illness at four schools. The staffing problems have caused significant challenges to some schools. Clearly staff ownership and commitment is essential for a successful project. Where key staff have moved or become unwell, impact has been limited.

The impact in many non-pilot schools has been very impressive, with enthusiasm, excellent, extremely positive staff attitudes and teachers beginning to address the issues of implementation as an integral part of the curriculum. For many, often experienced, staff this is the tool they have been looking for to teach CAD/CAM in a professional manner. The boost this has given to teacher morale cannot be underestimated and it is a great by-product of the scheme.

Teachers, even when trained, still lacked confidence to fully engage students in using the software; in part this is because of resource problems, in some cases it is a worry that they will not be able to answer the questions posed by students and in some cases they have not found time to organise the curriculum activities. Staff found the Pro/DESKTOP software demanding but once students were given quality access they responded to Pro/DESKTOP in a very positive manner. One teacher reported, 'After a few hours some pupils were so quick and confident, I was feeling inadequate. I must learn how to manage their expertise.' The issue of teachers' confidence to work in a position where they are not 'masters' is a recurring theme, especially with younger students.

The different types of electronics software have generated variable responses. Crocodile Clips and PCB Wizard have been well accepted and impact in terms of teachers' and students' use has been very impressive. The TechSoft software was well received and easily used by teachers and students with little training. The pilot schools launched in 1999 have found some packages more limited and have made little use of the software.

Trying to use the software without training has clearly failed and this reinforces the view that the training packages are becoming increasingly important. The development of whole school training has also developed and with 87 trained teachers who notified us of a change of school in the autumn term, it becomes clear that schools run a high risk of putting their teaching programmes on an unsound basis if only one teacher is trained. About one third of schools have now put a second teacher into a training programme and there are examples of whole departments undertaking training. This does lead to the software making a genuine impact.

The training of student teachers has been very significant, with more than 400 receiving training. The vast majority of these are teachers training in ITE establishments. Those on SCITT and graduate training programmes currently receive less access.

The performance of accredited trainers in Pro/DESKTOP has been good overall. A small number of accredited trainers' work is not always satisfactory and some tend to rush the training. The accredited trainer should also be prepared to support the teachers during the training period. The quality assurance system is now working well with useful feedback from the teachers and this data is used when deciding whether an accredited trainer can continue.

After a slow start there is recent evidence that ArtCAM training of teachers is developing, with greater interest from schools who have now established Pro/DESKTOP.

Students can use the Pro/DESKTOP software at home and this is considered one of the key elements of the programme in all schools involved in the CAD/CAM in Schools Initiative. However, many teachers still lack confidence to allow students to use the software at home. There appear to be a number of reasons for this. Some schools find the administration of this difficult for both physical and technical reasons; others are concerned about the student or parental abuse of the license, whilst some schools have found insufficient time to implement a home use programme. This issue of inclusion is a matter

Figure 3: Students' work exhibition at the conference.

of concern for teachers, because all students could not access the software they feel it inappropriate to allow any students to use the software at home. In some schools that have introduced focused teaching of Pro/DESKTOP as part of the scheme of work there is a reluctance to allow the software to be used at home as some students may move too quickly through the work. Whilst recognising many constraints that may influence teachers' decisions, it is considered essential that students in schools are encouraged to put the software on their own computer at home so they can design at leisure and can develop skills, which make using CAD software an integral tool when designing. Only when students have developed this high level competence will the full potential of the software be exploited. The establishment of CAD/CAM clubs has helped students who cannot access the computer at home.

Teachers remain concerned that using CAD software for examination courses may disadvantage candidates. This remains a concern and DATA has taken action to address this by explaining to all examination groups and their principal examiners about the software and its potential. In addition, DATA has offered awareness courses for all examiners with examination boards.

When launching Pro/DESKTOP into schools we advised schools to put the software on the school servers so that it could be used around the school and this aided access. This has caused considerable problems and although many networks now accept the software, it has not been feasible to find solutions for all networks. However, schools that are heavy users of CAD are finding increasing problems with the school networks, especially where networks do not have high capacity. It is becoming clear that design and technology departments may need their own departmental

Figure 4: Students' work exhibition at the conference.

server as the storage of images and student folders makes high demands on storage on the school's server.

The pilot schools with one laptop and those not included in the pilot project all report major problems of accessing computers in their schools. A typical design and technology teaching group consists of 22 or 23 students and best practice is where students are working in pairs in a formal teaching situation. Clearly once they are doing their own design work they need access to a computer on their own. When and for how long a student needs a computer is difficult for a teacher to determine, so major management issues are emerging in the use of the school's computing facilities. In schools where the computer facilities are in central areas that need booking, this is causing almost impossible situations to occur, especially in Key Stage 3. This is currently one of the major challenges for teachers trying to use CAD in school.

Where a design and technology department has their own suite of computers, or where computers can be easily accessed, then real progress and involvement of students is taking place. However, a number of schools have been identified where teachers have been trained to use the software and have used their personal computer at home, the department has no computers other than an old one that the software will not run on and the school computer facility is fully booked so the teacher has no access for their students. This creates an impossible position and means the teacher loses momentum. Sadly this is not isolated and teachers feel let down.

A second factor that has emerged is the lack of manufacturing equipment for translating the designs into manufactured products. Some schools have bought low specification equipment, which sadly leads to slow production and useful but limited activities. Others have more sophisticated equipment but producing whole class products is very time consuming. It is clear that a school needs a range of CNC equipment that carries out different manufacturing techniques. A small number of schools are linking to remote centres but once the outcomes increase then this puts too much pressure on the remote centre. The lack of quality manufacturing equipment in schools and its speed of operation is one of the major problems that teachers are facing. The development of MiniCAM has been very beneficial and many schools now use this software to link the Pro/DESKTOP to a manufacturing device.

The leading schools have now moved forward from creating what can be manufactured from simply wasting away of materials on a 3 axis basis to needing to generate 3D models through rapid prototyping. This fundamentally changes the making of models with the change from cutting away of materials to create models, to building up models that can then create more complex shapes. The introduction of affordable software for rapid-prototyping by Boxford has opened up a new field of work and as other new products emerge this will enhance the development of the subject by enabling students to realise their designs.

As more work is undertaken it becomes clear that using feature-based solid modelling software challenges the traditional approaches to designing and shows evidence of students' designing capability. Questions concerning the traditional assessment frameworks and their relevance when using such software is being questioned and there is a clear need for research in this area. DATA has commissioned Professor Richard Kimbell and his team at Goldsmiths to take an initial look at this before commissioning further research.

Some teachers and trainers are using the CAD software in a focused practical task culture rather than as a tool that aids designing and making in an innovative and creative mode. This strategy generates, in the short-term, better outcomes and provides much greater teacher control. However, it will limit and even restrict more holistic learning in the subject and its creative use of the software if more open-ended work is not overtaken. It is important that we do not generate another series of 'coat hooks' in CAD, when the software has such potential.

The experiences of using the software in the appropriate environment undoubtedly helps motivation very significantly, particularly with boys, and there is some evidence that able girls with a lack of confidence in drawing find the comfort of high quality outcomes through CAD very rewarding. In terms of attitude and

enthusiasm, there is no doubt the CAD/CAM in Schools Initiative is a big success. At this stage we have insufficient evidence on standards of achievement when using the software; in fact the very nature of the software is challenging the current modes of learning and framework for assessment. Much more research is required to determine what is changing and how it affects learning; once this is understood then perhaps a revision to the framework for assessment may be required.

The CAD/CAM in Schools Initiative has been well received by local industry; however, some schools report that local industry often does not have such good software. The initiative needs to address the issue of spreading the word with industry, especially with small medium-sized enterprises (SMEs).

Supporting teachers who become accredited or those who are considering becoming accredited is an important part of the programme. The CAD/CAM in Schools web site (www.cadinschools.org) is now fully operational with many useful features including the showcase of students' work and online assessment features. As this site becomes more populated it will provide additional information that will help schools. Teachers, however, have found the local support centres invaluable and these networks have been very supportive to local schools. The support centres were initially set up as hubs, however, it was clear many schools did not see the hubs as local centres for supporting other schools, therefore they were renamed in 2000/2001 as support centres for CAD/CAM in schools. These vary from universities, to LEA Curriculum Centres, to schools, some which are technology colleges, and others that are not, to individual consultants with a known track record. Selection of support centres has been based on the quality of the staff to support schools, their expertise in using the software and the geographical allocation. Although the samples in each category are small there is evidence that LEA support is particularly effective. In the school's area there is no correlation with the school's status and its effectiveness as a support centre. The value of the support centres cannot be underestimated and there is a good case for extending the number of support centres, however, they cannot operate without funding.

New developments in the programme

When DATA submitted the confidential evaluation and implementation strategy to the Government in 1998 it recommended a national training programme with supply cover for one teacher in every secondary school. Sadly in England the DfEE could not provide that level of support and a free market situation has developed. In Wales the National Assembly has funded free training with funds to support the schools to train one teacher in every school. This should result in a teacher in every school in Wales being trained by the end of the summer term 2001. The creation of four Welsh training centres has been very helpful in supporting that programme.

In March 2001 PTC released a PTC Student Mentor badge for students that teachers may use in a variety of ways to recognise expertise. This is aimed at encouraging expert student users who can help fellow students in their work and who may on occasions help teachers. This is based on observing teachers at work and seeing the need to recognise students who have expertise in using the software. It is hoped this will help develop a key skill of working with others.

DATA has also become aware of the inadequate advice available for planning appropriate teaching areas or rooms for teaching CAD/CAM in schools. There is clearly no single solution to the design of teaching areas for CAD/CAM, however, to stimulate the debate DATA has launched a design award competition with the hope of being able to illustrate new and workable concepts for teaching areas. This will also address the technical specifications that will help schools.

DATA has initiated some early research work on the influence of CAD/CAM on teaching and learning, however, this early research work will only identify area where major research is required.

There is a good case for extending the use of ArtCAM software, which has great potential, but as yet is significantly under used. In the next 12 months greater effort will be made to address this weakness in the programme.

Conclusions

- The CAD/CAM in Schools Initiative is having a major impact on the teaching of design and technology, by motivating staff and students.
- Many teachers now see the potential of using the software and their energy and commitment is quite outstanding, although a significant number still lack confidence to fully extend its use. There is a strong need for local support both technically and in terms of curriculum activity and management issues.
- Many teachers are not sure at what level to pitch work and what acceptable outcomes are. Development of exemplar work is urgently required.

- The access to computers in design and technology departments is clearly a major problem that must be addressed. The reliance of booking into school computer suites clearly does not work, and networking the software across the school network is proving unsatisfactory where heavy use is developing.
- The lack of appropriate manufacturing hardware is also a major concern and as the software is being used more the manufacturing deficiencies are growing and becoming a major frustration.
- The whole impact of releasing the software and training teachers is being lost in some schools because of a lack of any suitable computers and CAM machine tools.
- There is a clear need for a CAD/CAM specialist room or area within a design and technology teaching environment.
- There is a need for more and better curriculum materials, especially materials that are open ended and not simply focused practical tasks.
- Schools must increase the use of the software on students' home computers.
- Schools should consider the development of 'expert' groups of students to support fellow students and as a means of stretching the potential of the software.
- The CAD/CAM in Schools Initiative must work closely with examination bodies to increase their understanding so examinations are able to incorporate CAD/CAM work without any concerns about students being penalised.
- The fundamental issues that this initiative is identifying require significant research and this must be considered over the next 12 months.