Pro/DESKTOP in Schools: A pilot research study

RESEARCH

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Abstract

Following the launch and widespread dissemination of the CAD/CAM in Schools Initiative and Pro/DESKTOP (hereafter PDT) software, DATA recognised that the changes that are being brought about in children's designing are sufficiently profound to deserve careful research. This project is a small-scale exploration of the impact of this CAD initiative on children's designing and on the standards of work that can be achieved. Its aim is not to produce answers to these difficult questions. Rather its purpose is to clarify the questions that might need to be asked in a full scale evaluation. Because of the timing of this project and the looming examination demands in Years 11, 12 and 13, we were asked to focus on Years 9 and 10. This paper represents a brief synopsis of some of the major issues that emerged through the study.

Methodology

We were concerned primarily with what design and technology demands of youngsters and how this is serviced by the capabilities of the software. Accordingly, we devised three modes of enquiry.

First, we devised a design activity (based on a former APU test) that could be presented to students either as a 'normal' paper and pencil design activity or as a CAD activity in PDT. The activity was based on the design weakness of 'built-in' cooker timers, and invited students to design a portable cooking timer for the elderly, that can be set with a twisting motion and sound an alarm when the set time elapses. In either mode the activity was designed to take 90 minutes; the task was the same; the procedures were the same; and the assessment processes were the same. The difference existed in the fact that one was done on paper (with pencils) and the other was done (dominantly) in PDT.

Second, we devised an evaluation questionnaire for the students to complete once they had undertaken the design task. This questionnaire was in three parts. Part one invited students to agree/disagree (across a 1-4 Likert scale) with five statements about the activity that they had undertaken and why they had liked or disliked it. Part two invited students to agree/disagree with 13 statements about the desirability of designing in PDT. Examples here included 'because it's good for having ideas'; 'because it's good for visualising ideas'; and 'because it helps when I make things'. Part three was a free-response section, where students were invited to identify the three BEST things and the three WORST things about working in PDT.

Third, we developed an interview framework for students who had been taught PDT and for the teachers who had introduced them to it. This structured interview was conducted in all the test schools and additionally in a school in which we had not tested the students but in which we were advised that good practice existed. Interviews were conducted with students from Years 9-12 and included issues of familiarity with other software; experience with PDT; their pleasure and confidence in using PDT; what difficulties they have in using PDT; the benefits they perceive in using PDT; the advice they would give to others about using it; and how PDT might impact on the future of design and technology. The teacher interviews additionally included sections on their own experience in design and technology; about their training for PDT; and about their views of PDT as supporting students' capability in design and technology.

Student samples

Student performance data was derived from two categories of students; those being given high quality design and technology experience **without** use of PDT and those being given high quality design and technology experience **with** use of PDT. Our aim was to portray 'best practice' in design and technology and to seek to discern the differences arising in students' practice as a result of PDT use with Year 9 and Year 10 groups. Schools were selected following advice from DATA and LEA advisers, and the student samples were selected by the teachers in those schools.

In total, four schools and 62 students have been involved in this pilot study; two schools using only the PDT format; one school using only the paper and pencil format; and one school using *both* the PDT *and* the paper and pencil format. The student questionnaire was completed by all the students in the sample, and the interviews were conducted with a small group of students (usually four) and with teachers (usually one) in each of the schools.

Data management

All the student work was assessed, using the same general categories used in the APU survey:

initially and primarily
- holistic score

  and subsequently
  - identifying and specifying issues
  - generating and developing proposals
  - evaluating
  - communicating.

In each case we used a 1-4 rating (1=poor; 4=excellent), but for finer grading we subdivided each into 3, so that (e.g.) a 2 might be weak 2, a middle 2 or a strong 2. This

created in effect a 12 point scale. Within the marking team of four, initial samples of work were double marked and a moderation conference was used to calibrate standards. The resulting data were then entered and analysed in Excel.

The *questionnaire* responses (62) were also transferred into Excel for analysis.

The *interviews* were not recorded, but were conducted by two members of the research team who took notes on a prepared booklet. These notes were subsequently compiled in composite form in an Excel spreadsheet such that all answers to a single question could be scanned at a glance.

Issues arising

Our report to DATA includes an analysis of the performance data across the two samples and in relation to gender groups. However, for this brief paper it seemed more appropriate to focus on the issues that were raised by these findings, elaborated with the comments of students in the interviews and through the questionnaires.

i) State of readiness in schools

It is still very early days in the use of PDT, and practice is not yet well developed. Our schools sample was drawn from a short list of recommended schools since we were concerned not to reflect common practice but rather to identify leading-edge practice. Nonetheless, in the three schools in which we conducted the pupil design activities, we were somewhat surprised to find that it was the FIRST occasion on which the Year 9/10 students had been required to use PDT as a design and development tool.

ii) Enthusiasm and frustration

The questionnaire involved 13 factors through which students might identify what they liked or disliked about working with PDT. The responses here are clearly gendered, with boys expressing greater general approval (3.1) than girls (2.7). However, the individual factors that they approve or disapprove of are not gendered. The students are very clear about what they agree as the real strengths of PDT:

- it helps me to present my work professionally (3.5)
- it helps me to visualise ideas/ objects (3.3)
- it helps me to work accurately (3.3)

At the other end of the scale, they are equally clear about what they disagree with:

- it has good instructions to follow (2.1)

The questionnaire also has a free-response section, enabling students to identify the three BEST things about working with PDT and the three WORST things about working with PDT. There is considerable commonality in student responses.

BEST things identified:	(No. of times identified)
It is easy to use	17
It makes work look professional	16
It is accurate	12
It allows you to see what the product will look like	12
It makes my work look better than my own drawings	10

WORST things identified	
It doesn't let you do what you want to do	18
It is too easy to make errors	14
It is stressful/annoying/ confusing	13
It is difficult to master	12
The commands are hard to use	10

There is clearly something of a paradox here. How can all these students identify the operational difficulty of PDT whilst, at the same time, a large group report it as easy to use? This paradox was equally evident in our visits to schools to conduct the test activities. On one hand we found enormous enthusiasm (from staff and students) for PDT in the design and technology curriculum, but on the other hand, in students' work on the activities and in their interviews, we saw a great deal of evidence of their frustration at being unable to create the forms and images that they wanted.

So how can we explain this paradox; enthusiasm and motivation on one hand, and frustration on the other? It would be more normal for frustration to result in de-motivation and lack of enthusiasm. Yet it does not. We believe that part of the answer lies in the computer-game culture in which youngsters try time and time again to get past the evil goblin, but only succeed in getting eaten or squashed. Eventually – on the 53rd attempt – they find a way around the problem, experience the 'high' of success, and move on to the next challenge (the hairy spider). The early experience of PDT is not dissimilar, even to the extent of students having to 'go back and start all over again' because not only had they made a mistake, but they also could not see or find WHERE they had made the mistake.

Students' enthusiasm derives from the power of PDT for visualisation. All the interviews tell the same story. Students are very impressed by the amazingly 'real' images they

can create. They can 'see' objects on screen in a far more realistic form than they could possibly achieve with pencils. The equally powerful advantage of PDT for computer-based manufacturing, is hardly ever mentioned as a reason for student enthusiasm. We suspect that this is because they have not used it in that way – but have been introduced to it rather as a graphics tool. Nonetheless, our test activity provides ample evidence of students' ability to create strong product images, and these provide the antidote to the equally evident frustration.

iii) Design iteration

There is a wealth of literature that has established the importance for designers of reflecting on proposals as they develop. Recursive action and reflection is the cornerstone of student capability in design and technology and in normal circumstances is evidenced through the portfolio. In the test activity, the booklets were deliberately designed to maximise the impact of this iteration – encouraging students constantly to reflect and comment on their developing proposal.

In the paper and pencil form of activity it was easy to achieve this iterative growth – both in terms of student reflection on their *drawn* proposals, and equally on their written thoughts. These booklets exemplify the kinds of student responses that exist in good design portfolios.

The challenge for us in this project was how to achieve this level of reflective iteration in PDT, where the image sits 'silent' on the screen and separate from the ideas that led up to or grow from it.

We explored several approaches to creating a virtual portfolio – in Word and in Powerpoint – enabling students to save their work into them. Problems in both cases arose from the requirement to have another big software programme open alongside PDT, causing some machines to 'freeze' or 'crash'. In the end, we created a paper portfolio (similar to the pencil and paper booklet) and encouraged its use as a reflection tool linked to the point they had reached in their development on PDT.

This issue is clearly illustrated in the following two images that an individual student produced in the activity. The lack of reflective comment associated with either drawing, makes it impossible to understand what the student was thinking, and whether the move from (a) to (b) represented a sensible development.

(a) >>>>> (b)

Quite apart from the value to students of reflective comment – helping them to expose and clarify their thinking – there is clearly a related assessment issue. Where did the development in (b) come from? Is it a thoughtful development from (a), or was it simply copied from a neighbour?

There is a strong case for PDT to have an in-built 'portfolio' tool that will (i) allow the progressive development and recording of a *sequence of proposals* AND (ii) enable students to *overwrite comments* on them as they develop. The 'album' tool does not work in this way, and we did not see a single school that has been able to create anything equivalent to the flexible iteration that is commonplace in paper-based portfolios. As evidence of this, one has only to compare the work that students produced for this project on paper and on screen. The pencil-paper booklets are far richer design records than are the ones linked to PDT.

iv) Gender

There is conflicting evidence about the impact of PDT on gender groups. In one school, the teacher was absolutely convinced of a powerful gender effect. Girls – she thought – were quite prepared to follow the teacher through a set of instructions on a series of graphics exercises in PDT. Yet the boys were not. They wanted to play with it. Will it do

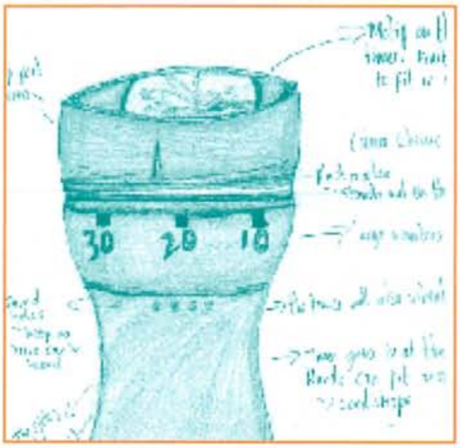

Figure 1.

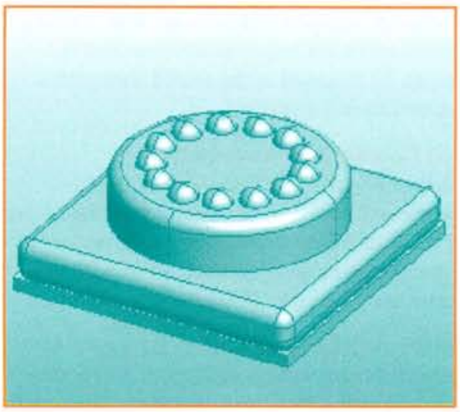

Figure 2.

that? What's that for? How does that work? Why can't we try this? The teacher was firmly of the view that the girls played safe while the boys played around. This resulted in the girls all achieving the desired end-point, but the boys having a very variable performance. Some failed to get anything done – while others found things out that the teacher herself didn't know about. This clearly gendered account is contrasted in our data with that from another teacher, who was convinced that all students managed it in much the same way:

> 'It's a real level playing fields girls/boys/ high ability/low ability/good drawers/bad drawers. Their background is irrelevant.' (Sch no.7)

The evidence from the test activity suggests that performance is indeed gendered, at least in the three schools in which we conducted the CAD format test activity. It is not that girls are better or worse than boys, it is that there is a clearly gendered *spread* of test scores. All the girls score a steady 6 or 7 (i.e. a mark range of 1) whilst the boys score from 2-10 (a mark range of 8). One explanation of these data would be that girls are indeed 'playing safe' while the boys play around; taking more risks both with their proposals and (by extension) with the limits of their understanding of PDT. This could easily lead to the dramatic variability in performance noted in the boys' data.

A noticeable feature of student performance in the activity concerns the kinds of design activity upon which students choose to focus. With students using the PDT form of the activity, in every case they focus on the outside form of the object. None choose to go inside and consider either the internal detail or the working mechanisms. Either the complication of this process, or students' lack of familiarity with doing it, or the lack of time during the activity appear to have encouraged students to focus their energies on the surface form of the timer.

In contrast with the CAD form of the test activity, in the paper/pencil format a student in school 1, chose to focus on the inner working detail of the electronic system and how it might be arranged in the overall form and operation of the product.

vi) Regular and irregular forms

A further noticeable feature of student performance is that all students working on the PDT form of the activity built their proposals around 'engineered' regular forms, typically cylindrical and cuboid forms.

In the pencil and paper form of the activity, several students move away from the regular and the engineered; exploring forms that, in terms of manufacture, would be achieved more through moulding and casting.

vii) Designing style

This problem may, in part, be one of initial unfamiliarity, but equally it may be that it is also a designing style issue. There is an accumulating body of literature that suggests that designing can be undertaken in very different ways, and that individuals display a preference for one style over another. Some students build up design solutions incrementally – working from small parts of it and gradually constructing a whole. Others conceive solutions as a whole and then 'take apart' their idea to explore how it might be composed. Some students are better at working with drawings, some with words and some prefer to make models and mock-ups. There are many pathways to salvation in design. One of the problems of current examination requirements (e.g. GCSE), is the implicit assumption that designing only happens in one standard way. Since designing is such an individual process, the danger exists that those whose style does not fit with the examination requirement, will be disadvantaged.

We suspect that this designing style issue is also raised by PDT, which lends itself to working in a particular way. The points we have raised above are indicators of this; for example its tendency to encourage external block modelling and the tendency for this to be based on engineered 'regular' forms.

This suggests to us that PDT, like every other tool in the designer's toolbox, is good for some things and not for others; suited to some kinds of designing and not to others; appreciated by some students and not by others. We note from the interview data, two samples that suggest the truth of this notion:

- two Year 12 students were ecstatic about the power of PDT in their A' Level work – both were male and both had applied for engineering degree courses
- a teacher commenting on the use of PDT with her Year 10 group reported that about 30% love it, 30% cope with it and 30% struggle.

In both these cases we suspect that preferred designing style underlies these reactions.

viii) Training issues

In our sample of teachers, the evidence was overwhelming that their training in the use of PDT was focused exclusively on developing their technical competence to operate the software. No time (or very limited time) appears to have been devoted to considering how best to introduce it to students – and in

particular, how to ease the gradient of the learning curve. Teachers' approaches in schools have typically reflected their own training and focused on the technicalities of the software.

In one school (in which we were not testing the students) we have observed a quite different approach in which projects have been planned specifically to bypass whole areas of the software, empowering students to get into designing from their very first lesson. The success of this approach suggests that teachers' training should incorporate detailed consideration of *how students will learn* PDT, rather than merely how it works and what it can do.

There is ample evidence that students learn the programme easier than their teachers do. This may be explained in many ways, but is clearly related to uninterrupted mouse-time (at home). We heard many accounts of students working whole evenings and weekends to create a particular piece of graphics.

The speed of assimilation by students is clearly something that teachers have to manage, and we applaud those teachers who rapidly recognised that the conventional teacher/learner relationship (teacher leading; student following) was not sustainable. Best practice here is clearly going to be based on a community of co-learners working together to understand it and make it work. The student mentor programme is another sensible response to the reality of this situation.

ix) Assessment issues

The principal issue here is the extent to which the use of PDT changes the normal rules of engagement for the assessment of project work in design and technology. The issue appears to us to present itself, once again, as the old problem of process versus outcome. Are we looking at the *process* of development and resolution or are we looking at the quality of the final solution? We are firmly of the view that the quality of the development process must be at the heart of student assessment. Since PDT does not have a built in portfolio facility, all kinds of development may be undertaken by a student on a project and lost unless the student goes out of his/her way to create a continuous series of hard copies that illustrate their pathway of development.

This takes us back again to the 'tracking' issue that we discussed earlier in the context of design 'iteration'. In normal design and development, the paper portfolio serves a double function:

- it allows the student continuously to develop ideas and reflect on them – thereby encouraging further development
- it allows the teacher/examiner to 'see' the development of a student's thinking – it is a manifestation of the thought processes in action.

In principle we see absolutely no reason why a portfolio should not be submitted on a disk, BUT this carries the proviso that it must equally be a requirement to be able to see (on screen) the progressive development of the student's thought processes on the product. Capability assessment is not changed by the transition from paper to screen. In either environment it must be possible to 'see' the student's development process. If that is not currently possible in PDT, then other approaches must be used, but it would be a major step forward if a portfolio tool could be developed within PDT.

Conclusion

In the schools that took part in this small study, we found enormous enthusiasm for the development of Pro/DESKTOP in design and technology. As we reported above, the principal reasons for students' enthusiasm lay in what they saw as its real strengths:

- it helps me to present my work professionally
- it helps me to visualise ideas/objects
- it helps me to work accurately.

Teachers too were excited by the potential of this new tool, commenting that students were more enthusiastic when working in PDT 'they love working with it, it's brought out a new aspect of design and technology for them'. As a result of this small study, we have developed for DATA a list of research and development priorities that we believe would support the dissemination of good practice with Pro/DESKTOP.

Yet perhaps it would be best in this short paper, to leave the last word to the students. We asked them what advice they would give to other students who were about to learn PDT. They commented as follows:

> 'try out ideas – don't be scared; be patient – don't be discouraged; don't panic – take time to figure it out; listen carefully to instructions; and get LOTS of mouse time.'

We also asked them what advice they would give to the teachers who were about to introduce PDT to other students. They commented as follows:

> 'get on a GOOD course; teach in smaller classes; get pupils involved in demonstrations; go slowly – then use us as teachers – some of us are already really quick and can help others.'