e-scape portfolio assessment

a research & development project for the Department for Education & Skills (DfES)
and the Qualifications and Curriculum Authority (QCA)

phase 1 report

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June 2005

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1 project e-scape context

The story that underpins this project brings together a number of strands of educational debate:

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a) design & technology

In 1999, the latest version the National Curriculum was published, including the most recent formulation for design & technology. One of the welcome additions to each of the subject areas for NC2000 was the articulation of 'importance' statements, in which the vision of subjects is encapsulated. The Statement for design & technology reads as follows:

> *The importance of design and technology*
>
> *Design and technology prepares pupils to participate in tomorrow's rapidly changing technologies. They learn to think and intervene creatively to improve quality of life. The subject calls for pupils to become autonomous and creative problem solvers, as individuals and members of a team. They must look for needs, wants and opportunities and respond to them by developing a range of ideas and making products and systems. They combine practical skills with an understanding of aesthetics, social and environmental issues, function and industrial practices. As they do so, they reflect on and evaluate present and past design and technology, its uses and effects. Through design and technology, all pupils can become discriminating and informed users of products, and become innovators.*
> *(DfEE 1999)*

At the time of publication, the DfEE, in concert with the Design & Technology Association (DATA) established a Strategy Group for design & technology, charged with the task of steering the subject through the following years. The group undertook a number of development tasks, including an externally commissioned review of the literature concerning the impact of Design & Technology and a review of new technologies that might be encouraged to support the growth of design & technology in the immediate future. One task - undertaken by members of the group itself - was to review the internal coherence of design & technology as presented in NC2000, with particular regard to the match between the vision statement, the Programmes of Study (PoS) and the Attainment Target (AT).

It was noted that the vision statement encapsulates the need for creativity, innovation and teamwork in design & technology.

- 'intervene creatively'
- 'creative problem solvers'
- 'members of a team'
- 'become innovators'

It was also noted that whilst the PoS is less clear on these points, there is at least an implicit recognition of their importance and the scope or flexibility to interpret these imperatives into school curricula. However it was noted that the Attainment Target is starkly bereft of any reference to, or recognition of, these key factors.

Beyond NC requirements, related problems were evident with GCSE assessments, partly through the syllabus specifications themselves (which lack reference to innovation, creativity and teamwork), and partly, inadvertently, through the impact of 'league-tables'. Teachers, departments and schools are now almost as dependent upon the GCSE results as are their learners, and a typical response in schools is that teachers impose ever-more rigid formulas on student project portfolios to guarantee success. The concern of the DfES Strategy Group was that as GCSE project work portfolios become more formulaic, innovative learners may be penalised by comparison with well organised, rule-following learners. This has the result that - in relation to the design & technology vision statement - the wrong learners (or at least some of the wrong learners) are rewarded with the best grades in GCSE assessments.

b) assessment for learning

Whilst assessment takes many forms and has many purposes (eg summative, diagnostic, evaluative, formative), a particular focus has recently been placed on formative assessment. This is not assessment for award and certification purposes, but is rather concerned with assessment to improve and enrich the learning environment. The QCA view of Assessment for Learning provides the following checklist for effective practice:

- *sharing learning goals with pupils*
- *helping pupils know and recognise the standards to aim for*
- *providing feedback that helps pupils to identify how to improve*
- *believing that every pupil can improve in comparison with previous achievements*
- *both the teacher and pupils reviewing and reflecting on pupils' performance and progress*
- *pupils learning self-assessment techniques to discover areas they need to improve*
- *recognising that both motivation and self-esteem, crucial for effective learning and progress, can be increased by effective assessment techniques.*

(QCA May 2005)

Black et al (2003) informed this debate with the launch of their book "Assessment for Learning: putting it into practice", and the Tomlinson Report "14-19: Extending opportunities, raising standards" took the debate further. The argument from both is essentially that too much time, effort and expense is tied up in external assessments and that more attention should be devoted to the kinds of assessment that are classroom and teacher based, and that are designed to inform the processes of learning and teaching. Assessment arises in almost every exchange between teacher and learner, and operates as a feedback device,

informing the teacher of any mis-understandings, or half understandings that stand in the way of learners' progress.

> *"formative assessment can occur many times in every lesson"*
> *(Black P & Harrison C 2004)*

Seen in this way, formative assessment, or *assessment for learning* helps the teacher to shape their next intervention and it casts the debate on assessment into a personalised form – customised towards the needs of individual learners and their progress. Phrases such as 'individualised assessment' and 'pupil-centred assessment' thereby become key parts of the lexicon. As OFSTED has pointed out:

> *"Regular feedback by teachers to pupils, with a note of their strengths and weaknesses, significantly enhances pupils' progress."*
> *(OFSTED May 2003)*

But achieving these benefits increases substantially the requirement for interaction with pupils and presents teachers with a significant increase in the amount of information they have to manage. Within this emerging field, we believe that there is enormous potential in the use of digital systems to support teachers and learners with appropriate tools to manage these rich and complex data. It is something of a paradox that assessment reform is being led by groups with limited understanding and experience of digital systems, whilst digital development is pressed forward by groups with limited understanding and experience of learning and assessment.

We believe that sympathetically designed digital systems could provide both a framework of support to better understand these processes of assessment as integral to learning, and at the same time provide flexible tools to manage and implement this (largely) new emphasis.

c. e-learning

The present government has embarked on a major programme to digitise many of the activities and services it offers, driven by (among other things) the promise of greater control, improved efficiencies, cost savings and better standards of service. This focus on developing new ICT systems straddles many aspects of government from (e.g.) taxation, registration, legislation, communication, health and education.

These initiatives have developed as largely isolated programmes and we have now reached a point where it has become clear that there is a pressing need to, and significant additional benefits to be gained from, joining these systems up. An obvious common denominator to facilitate a more connected approach is the individual citizen and recent e-government proposals anticipate binding existing systems together through new bridging services such as personalised e-learning systems and e-identity cards.

E-learning is a term that has emerged to describe a wide range of digitally enhanced educational experiences; from a straightforward internet search or the completion of a simple screen-based multiple choice question, to full blown multimedia managed learning environments providing access to complete courses.

With the new focus on joining up e-services, e-learning has gained an additional, longitudinal dimension through the proposal to provide “personal online learning spaces”. Interestingly, this requirement is identified not just by the DfES but comes as part of an overarching policy direction from the Prime Minster’s Strategy Unit. In a document entitled “Connecting the UK: the Digital Strategy”, action1 is defined as “Transforming Learning with ICT” and describes the need for everyone to have an electronic portfolio for lifelong learning:

> *Over time we should see the technology join up better across institutions, so that this is available to learners to build on wherever they go – to further learning, or to work-based learning. And in the future it will be more than simply a storage space - a digital site that is personalised, that remembers what the learner is interested in and suggests relevant web sites, or alerts them to courses and learning opportunities that fit their needs. We will encourage all organisations to support a personal online learning space for their learners that can develop eventually into an electronic portfolio for lifelong learning. (Prime Minister’s Strategy Unit. 2005)*

Developing a similar theme, the DfES e-learning strategy identifies the provision of a centralised e-portfolio as an important priority for reform, second only to the provision of the infrastructure to make it work:

> *Our second priority extends this personalised support to learners, helping with all stages of education and with progression to the next stage. We will encourage every institution to offer a personal online learning space to store coursework, course resources, results, and achievements. We will work towards developing a personal identifier for each learner, so that education organisations can support an individual’s progression more effectively. Together, these facilities will become an electronic portfolio, making it simpler for learners to build their record of achievement throughout their lifelong learning. (DFES e-strategy 2005)*

It is important to recognise however, that these centralised, regulated developments arise in the somewhat more anarchic and dynamic world in which young people live. Here technology is integrated into a wide range of social, cultural and productive aspects of young people’s lives to the point where digital technologies have become a ubiquitous element of learners’ experiences outside the classroom. One example of this phenomenon is provided by research conducted by MORI for the Nestlé Social Research Programme into the role of mobile phones in young people’s lives.

Access to:	*Year 9-10*	*Post 16 in full time education*
Mobile	*95%*	*99%*
Internet	*85%*	*95%*
e-mail	*70%*	*90%*

(Haste H. 2005)

Moreover it is not just that they have access to the technology, they also use it; with 9 out of 10 texting at least once a day and over 25% taking photos daily.

d. e-learning in design and technology

Developing effective approaches to e-learning (embedding ICT) within curriculum subjects has proved to be a significant challenge, and DfES is currently working on a number of programmes to promote more effective and widespread integration of ICT within subject teaching and learning. Design and technology has shown that this integration is possible, and statistics from the annual DfES survey of ICT in Schools reflect increasing use and positive effects.

Use of ICT in areas of the curriculum

Secondary	*d&t*	*English*
substantial	*62%*	*19%*
some	*35%*	*69%*
little/none	*3%*	*12%*

Positive effect of ICT in areas of the curriculum

Secondary	*d&t*	*English*
substantial	*64%*	*24%*
some	*32%*	*63%*
little/none	*4%*	*13%*

(DfES 2003)

The statistics in this DfES survey suggest that design & technology makes the best use of ICT when compared to other secondary subjects, and this is reinforced in the OFSTED report of 2004.

"Secondary design and technology (D&T) departments continue to make widespread and effective use of ICT in their teaching."
(OFSTED 2004)

This report goes on to note the range of ICT related activities that are typical in design & technology

Increasingly, pupils are developing competencies in:
- *using the internet to carry out investigations*
- *recording ideas and information using attractive graphics*
- *simulating and modelling ideas as they develop solutions to problems*
- *using computers and related machinery to design and make products to high levels of sophistication*
- *using computers to control systems.*

(ibid)

We note however, that this list – pleasing though it might be – tends to place the focus for learners use of ICT in design & technology onto doing and recording activities; 'to control' 'to simulate' to manufacture'. There is little here that suggests the ICT is being used formatively to generate, initiate, stimulate, and develop learners' ideas. Nor is there much scope in this list for acknowledging any ICT role in relation to learners' reflecting, reviewing, critiquing and evaluating their ideas. These are the designerly, intellectual qualities that lie at the heart of learner portfolios in design & technology.

e. portfolios - what they are and what they aren't

The concept of a ' portfolio' is problematic, arising in part from the fact that the term portfolio means very different things to different people. The potential for different interpretations is increased by the use of portfolios as an assessment tool, and complicated yet further in the context of e-learning, where 'e-portfolio assessment' has become a minefield of misunderstanding and confusion.

As a starting point, we recognise that there are many purposes to which portfolios might be applied. These have been articulated by IMS Global Learning (developing specifications for e-learning environments) in the following terms.

- *Assessment portfolios*
- *Presentation portfolios*
- *Learning portfolios*
- *Personal development portfolios*
- *multiple owner project portfolios*
- *working portfolio*

(IMS Sept 2004)

For the purposes of this project we believe it would be helpful to clarify our understanding of what a portfolio is and how it works in design & technology. Whilst d&t portfolios have been refined over the years and attuned in particular to the priorities of assessment, nonetheless, the essence of a d&t portfolio involves a mix of what the IMS lists as an assessment portfolio, a learning portfolio and a working portfolio.

Through custom & practice in design & technology it is possible to observe several forms of what a portfolio might be.

i. The most common meanings of 'portfolio' defines it as something akin to a box-file into which the learner (or perhaps the learner's teacher) can place work to demonstrate that certain operations, or skills, or processes have been experienced. Viewed in assessment terms, the learner's portfolio becomes a collection of evidence that is then judged against some rubric to arrive at a mark or a level. A portfolio of this kind is conceived as little more than a ***container*** for evidence.

Translated into the e-portfolio world, it is possible to conceive of many ways in which the evidence being 'contained' could be enhanced through the application of database or spreadsheet systems, which might even be designed to automate the process of containment, standardising, streamlining and potentially removing the need for human interaction.

ii. A somewhat more sophisticated view of portfolio arises from process-rich areas of the curriculum, where teachers encourage students to document the story of a developing project or experience. This results in learners ***reporting*** what they have done at various points in the process.

In this kind of 'presenting' or 'reporting' e-portfolio, it is not unusual for students to use linear digital presentation technologies - eg powerpoint - to give a blow by blow account of where they have been in the project - and how they finally got to the end.

However, whilst these two accounts might be seen as part of the picture, neither of them captures the dynamic capability dimension that informs our view of a design & technology portfolio.

The central problem - in both cases - is that the portfolio construction is conceived as a second-hand activity. First you do the activity - whatever it is - and then afterwards you construct a portfolio that somehow documents it. The portfolio is a backward-looking reflection on the experience.

iii) A third and far richer view of the concept of the portfolio is evidenced in schools (particularly in design & technology) where teachers have embraced the challenge of linking learning and working concepts of the portfolio to the more commonplace assessment portfolio.

In this rich form, the portfolio is transformed into an entity that is integrated into and grows dynamically with the project - and in the process it shapes and pushes forward the project. The best analogy is neither a container nor a reported story, but is rather a ***dialogue***. The designer is having a conversation with him/herself through the medium of the portfolio. So it has ideas that pop up but may appear to go nowhere - and it has good ideas that emerge from somewhere and grow into part solutions - and it has thoughts arising from others comments and reflections on the ideas. Any of these thoughts and ideas may arise from procedural prompts that are deliberately located in the activity to lubricate the dialogue. Looking in on this form of portfolio is closer to looking inside the head of the learner – revealing more of what they are thinking and feeling, and witnessing the live real-time struggle to resolve the issues that surround and make up the task. Importantly, this dynamic version of the portfolio does not place an unreal post-activity burden on learners to reconstruct a sanitised account of the process. Creative learners are particularly resistant to what they see as such unnecessary and unconnected tasks, and this significantly accounts for their underperformance in portfolio assessments that demand such post-hoc story telling.

But real-time dynamic portfolios are not tidy, nor is it possible to present them in a pre-determined powerpoint template. It is more like a designers sketchbook - full of notes and jotting, sketches, ideas, thoughts, images, recordings and clippings. These manifestations are not random - but are tuned to the challenge of resolving the task in hand. And the point of the portfolio is that the process of working on it shapes and develops the activity and the emerging solution.

Our three categories of portfolio are somewhat dissimilar to those identified by Ridgway, McCusker and Pead for Nesta Futurelab in their literature review of e-portfolios.

> *There are three distinct uses for portfolios:*
> *• The first is to provide a repository for student work;*
> *• the second is to provide a stimulus for reflective activity – which might involve reflection by the student, and critical and creative input from peers and tutors;*

> *• the third is as showcase, which might be selected by the student to represent their 'best work' (as in an artist's portfolio) or to show that the student has satisfied some externally defined criteria, as in some teacher accreditation systems (eg Schulman 1998). (Nesta-Futurelab 2005)*

Whilst their 1st category is the same as ours, their 3rd seems to be little more than an extension of this – allowing for the repository to contain work selected over time and used – inter alia - for assessment purposes. It is a container with some display potential. Furthermore, whilst their 2nd category contains some elements of dialogue potential, it does not capture the dynamic creative essence of portfolios as we see them operating in design & technology.

These disagreements demonstrate the thorny territory that is conjured-up merely by the use of the term e-portfolio. We are very conscious of this issues and it demonstrates the absolute necessity of being very clear about what is proposed within phase 2 of project e-scape.

f. e-assessment and Awarding Body innovation

In design & technology alone, approx half a million students are assessed annually using portfolios of the kind we have described as a 'dialogue', with learners developing a design solution to a task of their own choosing, and simultaneously telling the story of their development process. Approx 50% of their GCSE marks are allocated on the basis of the quality of their portfolio.

Awarding Bodies responsible for these assessments – particularly at GCSE – are increasingly seeking to exploit the power of digital technologies. And there are at least two 'drivers' for these initiatives;

Awarding bodies have faced the challenge of students using commercial software systems (particularly CAD/CAM) as part of their product development work, and increasingly teachers have sought to obtain permission to submit this work digitally. Whatever view one takes of what the portfolio is, it seems logical that if the work is being done digitally, it seems somewhat perverse - and inauthentic - to then print it all out as though the work had been done on paper.
Quite apart from the issue of authenticity, there is a practical issue. Awarding Bodies can see the advantage of submitting such work digitally (eg on a disc or via a secure website) simply because of the reduced labour, resource (eg paper) and costs (eg postage) involved.

As regulator of the activities of Awarding Bodies, the Qualifications and Curriculum Authority (QCA) has developed its own strategy for addressing e-assessment. QCA's 5-year objectives are that:

by 2009:

- *all new qualifications should include an option for on-screen assessment*
- *all awarding bodies should be set up to accept and assess e-portfolios*
- *most GCSEs, AS and A2 examinations should be available on-screen*
- *National Curriculum Tests should be available on-screen*

- *on-demand assessments will begin to be a feature of GCSEs*
- *10 new qualifications, designed for electronic delivery and assessment, should be developed, accredited and live*

Towards this objective, the following timeline will apply:

by 2005
- *Field trials successfully completed by awarding bodies in at least two subjects*
- *75% of basic and key skills tests delivered on-screen*

by 2006
- *A code of practice, plus audit and other regulatory criteria, is developed*
- *AQA, OCR and Edexcel offer live GCSE exams in two subjects each*
- *Pilot of at least one qualification, specifically designed for e-assessment*

by 2007
- *10% of GCSE examinations administered on-screen*

by 2008
- *On-demand testing introduced for GCSEs in at least two subjects*

by 2009
- *e-assessment becomes increasingly routine*

(QCA 2004)

The importance of e-portfolios within this strategy has been underlined by OFSTED in their recommendation concerning the development of ICT in schools. They make clear that at the school level there is a need to:

"develop electronic portfolios of pupils' work alongside the use of web- or intranet-based applications that enable assessed work to be easily accessed by teachers, pupils and parents"
(OFSTED 2004 [ii])

2 Starting points

a. DfES project 'assessing design innovation'

The problem described in 1(a) above - of student GCSE portfolios in design & technology becoming formulaic and teacher controlled – may be interpreted in relation to the three kinds of portfolio outlined in 1(e) above. The problem being addressed by the Design & Technology Strategy Group was that assessment pressures – linked to the publication of league tables – have distorted the nature of the d&t portfolio. Essentially - in order to ensure success for learners, teachers have increasingly shifted from the dynamic 'dialogue' notion of portfolio to the more passive 'reporting' form that is easier to control and present neatly. Teachers have felt obliged to control the portfolio to maximise students' opportunity for getting marks.

The Strategy Group recommended that research be undertaken to examine the extent to which - and the ways in which - innovation and team-work might be more fully recognised and rewarded in assessment processes, particularly within GCSE. The Technology Education Research Unit (TERU) at Goldsmiths College was asked to undertake the work and develop a system of assessment that would measure and reward design innovators. The project was launched in Jan 2003 and concluded in Dec 2004. The thrust of our work arising from this brief has been to reinvigorate a view of portfolio assessment that transforms it back into dynamic dialogue mode.

The principal outcome of the project was a developed portfolio assessment system that sat somewhere between a formal examination and a piece of coursework. It was designed to operate in 6 hours - typically 2 mornings - and presented learners with a design task that was to be taken through to a prototype.

The following structure is characteristic of the activities developed. The task ('light fantastic') centres on re-design of a light-bulb packaging box, so that, once the bulb is taken out for use, the package/box can be transformed into a lighting feature - either by itself or in association with other 'liberated' light-bulb package/boxes.

(i) read the task to the group and (through brief Q&A) establish what is involved
(ii) explore a series of 'idea-objects' on an 'inspiration table' and in a handling collection designed to promote ideas about how boxes / packages / containers might transform into other forms and functions.
(iii) put down first ideas in a designated box in the booklet
(iv) working in groups of 3, learners swop their booklets and each team-mate adds ideas to the original
(v) team-mates swop again so that each team member has the ideas of the other two members
(vi) booklets return to their 'owner' and team members discuss the ideas generated
(vii) the teacher introduces the modelling/resource kit that can be used throughout the 2 mornings
(viii) learners develop their ideas in the booklet - and/or through modelling with the resources
(ix) learners stop to reflect on the user of the end product and on the

context of use, before continuing with development

(x) at intervals, learners are asked to pause and row a dice - with questions on each face. The questions focus on procedural understanding eg “how would you ideas change if you had to make 100?' and learners answer the questions in their booklet

(xi) photographs are used at approx 1 hr intervals to develop a visual story line to illustrate the evolution of models & prototypes

(xii) at the end of the 1st morning, learners - and their team members reflect on the strengths and weaknesses of their evolving ideas

(xiii) the 2nd morning starts wth a celebration of the work emerging from day 1. This is based on post-it labels that highlight learners' thoughts about the qualities in their ideas

(xiv) further prototype development

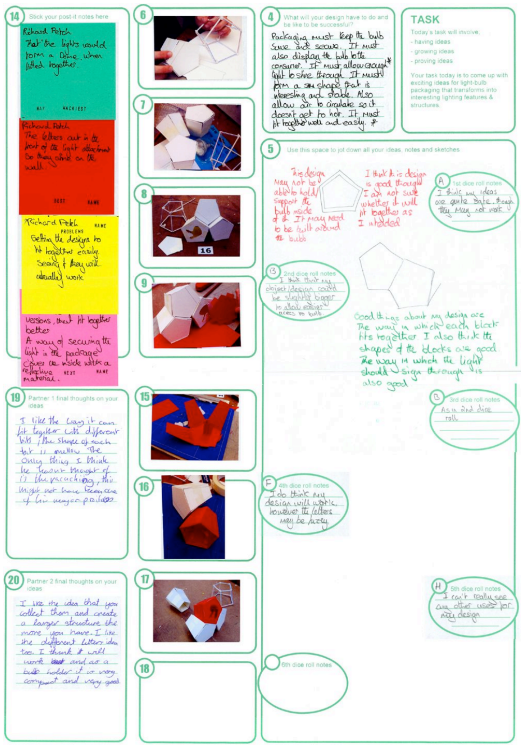
(xv) regular hourly photos and pauses for reflective thought on strengths and weaknesses

(xvi) final team reflections, when (in turn) team members review each others' ideas and progress

(xvii) individually, learners then 'fast-forward' their idea illustrating what the product will look like when completely finished and set-up in context

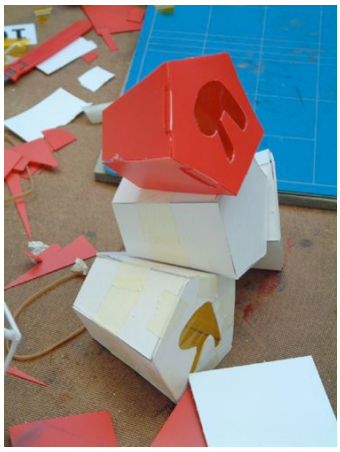
(xviii) learners finally review their work from start to finish.

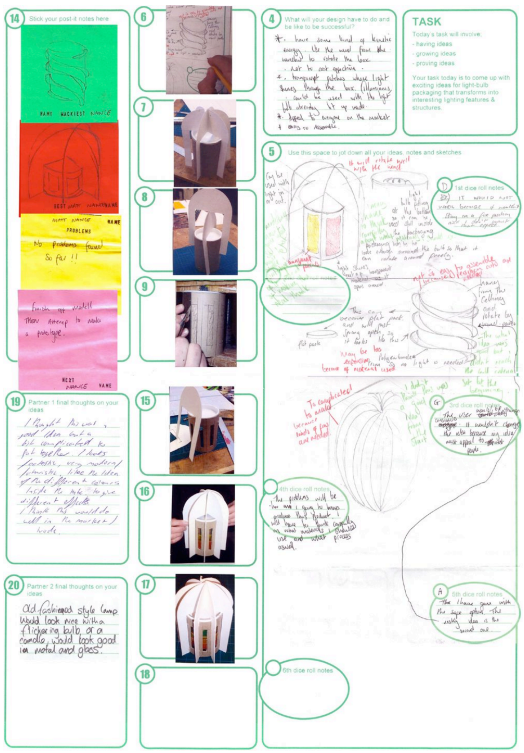
All the learners’ work was structured into an A4 workbook that folded out to become an A2 sheet. The activity was designed to be administered by teachers in ordinary design & technology facilities. The workbooks were carefully designed to unfold throughout the activity, ensuring that students always had sight of the instructions for the sub task they were currently working on and the work they had just completed.



The illustrations below show two learner booklets. The first is for ‘your-name in lights’ and the photo story-line demonstrates the progress of the ideas from inception to final prototype. It is clear that the strength of this idea emerges predominantly through the medium of 3D modelling. The 2nd booklet illustrates a student who is equally comfortable with developing ideas through drawings and with 3D modelling. In both cases, the booklet allows us to ‘see’ their very different modes of working in operation

The concept here was for light-bulb packaging to become pentagonal and tapering, allowing ‘used’ boxes to build into a spherical lighting feature that – when illuminated by a light at the centre - projected letters around the wall. The learner’s strap-line for it was ‘your name in lights’.





In this case the learner developed his prototype using a combination of graphic modelling and 3D modelling, supported by a considerable amount of reflective comments and critique.

The outcomes of learners' work during this project was most encouraging. It was possible to demonstrate that different levels of innovation were identifiable in the work and that the best work was highly innovative. Critically, the consensus of teachers and learners was that the portfolio system acted as a dynamic force to drive the activity forward with pace and purpose. A second round of trialling was undertaken in association with the four Awarding Bodies for England and Wales. This involved 8 schools and approx 300 learners, all of whom did two activities. The data from this trial is fully reported in the project report (Kimbell et al 2004).

In the process of working on this project, we were able to identify other features of the portfolio – or of the setting within which it works – that significantly impact on its effectiveness. And the key one is the learning and teaching culture created by the teacher in the workshops and studios in which learners operate. This culture in turn influences each of the following features:

• motivation

For learners to be fully engaged and performing at their best requires levels of motivation that – in design & technology at GCSE level – must be maintained over an extended period (typically 6 months). Our 6 hour activity was equally dependent upon generating enthusiasm for the task and we used a number of techniques to generate and maintain it.

• ownership

Who is the portfolio seen to belong to? Is it the learner's, or the teacher's, or the department's, or the GCSE Awarding Body's? Learners' sense of ownership of the work is typically a pre-requisite for fully engaged performance.

• environment
For dynamic creative work to be generated by learners, the environment must be one in which the working atmosphere in conducive to those values. In terms of our project, this required teachers to be open not just to learners' ideas but also very flexible in how they encouraged learners to express and develop them.

• Ideas
At the heart of dynamic creative portfolios are ***ideas***. We were explicit in encouraging learners to have ideas, grow their ideas and prove their ideas. Equally we encouraged teachers to facilities these features of learners' performance.

Each of these four will be seen to have an e-quivalent within the e-scape project.

b digital enhancement

It was during the development of the activities for the previous project (assessing design innovation) that we became aware of the potential for digital enrichment of the activity. Learners increasingly use digital technologies as part of their work in design & technology. They use digital photography to record their designing and manufacturing processes. They increasingly use the internet for information searches; computer aided design (CAD) systems for design development work; and - in some cases - this extends to computer aided manufacturing (CAM). Also, they increasingly access, complete and store their work on school networks and intranets that allow access from their home computers. This extends the working environment beyond school workshops and studios and allows them time-unlimited access to their work. It also broadens the tool set that is available to them to envision, manipulate and develop their ideas, and in the process it raises important cultural issues associated with the origins of ideas, the ownership of work, team-work and plagiarism.

These thoughts led us to develop a proposal to QCA/DfES for a digital approach to portfolio assessment. Learning activities in design & technology studios and workshops are increasingly influenced by digital technology, and we believe that the portfolio assessment system that we developed in the DfES "Assessing Design Innovation" project provides a useful model to explore the possibilities of extending digital working in design & technology into digital assessment of learners' performance.

This development involves introducing new technologies into the classroom, as well as extending the range of existing technologies into the domain of assessment. The expanded use of these digital technologies into the realm of assessment will have some serious impacts on current approaches to teaching and learning . We are absolutely committed to undertaking these developments without compromise to the underlying concepts of design & technology as expressed in the 'importance of design & technology' statement in Curriculum 2000. Indeed we believe that the work may contribute to taking forward our collective understanding of the power of design & technology as a learning vehicle.

c 'peripheral' digital technologies

One of the problems surrounding the use of digital technologies in schools is that teachers tend towards the assumption that this needs to take place in a computer suite, rich in desktop or laptop machines where learners work with a keyboard and screen.

Our starting point is very different.

We start from assumptions about the nature of design & technology – the circumstances of which are almost always workshops and studios. Two of the constants of these typical design & technology spaces are that

- they are full of materials, apparatus, machinery, and specialist work-spaces
- they are associated with the detritus of manufacturing

They therefore make challenging locations for computers, keyboards and screens. First there is not enough space; second the space is not clean (glue, paint, flour & water, sawdust) and third learners themselves get oily or painty or gluey or floury fingers that are not then ideally suited to keyboard use.

For all these reasons we do not believe that digital enhancement of the designing activity will involve computers, keyboards and screens. At least we do not believe that these tools will be at the leading edge of activity. Rather we think that peripheral, back-pocket technologies will be more appropriate: mini digital cameras, digital pens, digital PDAs.

At least at the 'input' level these technologies enable activities in workshops and studios to go ahead almost as normal. They don't take up too much space and (because they can be pocketed) they are no too sensitive to the clutter of the working space. Our trials in schools will show how realistic this turns out to be.

Interestingly, students at KS4 now (almost universally) have access to mobile phones, a significant proportion of which have digital cameras as a built-in feature. As the telecoms companies race to differentiate their systems through enhanced features, the current distinction between handheld PDAs and mobile handsets is disappearing as the two previously unconnected technology strands merge. While 'smart' phones, with all the features of a PDA, are currently not marketed to pupils, camera phones are becoming more ubiquitous and other 'smart' features will increasingly work their way onto phones for children. This trend will be all the quicker if it is seen (or marketed) as providing valuable tools for learning, thereby justifying additional parental expenditure.

In short, we are witnessing the growth of 3rd generation computing. Mainframe computer technologies of the 1960s and 70s gradually faded with the emergence of 2nd generation 'desktop' computers. These completely transformed our working relationship with computers – providing us with far greater interactivity, apparently unmediated by the programmers whose services had formerly been essential. We could 'drive' our own 2nd generation computers in the 1980s and 90s . As the technologies shrank, the growth of laptop computers particularly in the final decade of the 20th C did not materially change our relationship to computers. They operated merely as slightly (very slightly) more mobile versions of the desktop. But the new 3rd generation of computers is radically different. They are FAR more mobile, are equally powerful, and can now genuinely be regarded as 'back-

pocket' computers. As such, they are in the process of transforming – once again - our working relationship with computers. The transition to 3rd generation mobile technologies will be just as dramatic as was the transition from the 1st to the 2nd generation. In the contexts of learning, teaching, curriculum and schools, these transformations will be profound. We believe that the e-scape project will provide us with many insights into the educational implications of this 3rd generation.

3 brief for project e-scape

The brief for phase 1 of project e-scape can be summarised as follows:
"QCA intends now to initiate the development of an innovative portfolio-based (or extended task) approach to assessing Design & Technology at GCSE. This will use digital technology extensively, both to capture the student's work and for grading purposes. The purpose of Phase I is to evaluate the feasibility of the approach...'
(QCA Specification June 2004)

Phase 1 of the project (Nov 04-Jun 05) has been - in several senses - a "proof of concept" phase, to explore the feasibility of the concept outlined above. This proof of concept operates at four levels:

i) technological
Concerning the extent to which existing technologies can be adapted for assessment purposes within the portfolio system as currently designed for the DfES "Assessing Design Innovation" project. This will include the applicability of other international work in this area and of any relevant system standards.

ii) pedagogic
Concerning the extent to which the use (for assessment purposes) of such a system can support and enrich the learning experience of design & technology

iii) manageable
Concerning issues of making such assessments do-able in 'normal' d&t classrooms / studios / workshops
- the training / cpd implications for teachers and schools
- the scalability of the system (including security issues) for national implementation

iv) functional
Concerning the factors that an assessment system based on such technologies needs to address;
- the reliability & validity of assessments in this form
- the comparability of data from such e-assessments in d&t with non e-assessments

Each of these four 'proof of concept' deliverables will be explored in schools through a series of small-scale trials. This report – covering the four 'proof of concept' factors – was the required 'deliverable' for phase 1 of the e-scape project. However, having done that in section 5 of this report, we felt the need to go further and detail a specification of what a working system might be like. This specification – in section 6 of this report – then becomes our working template for developing the prototype in phase 2 of project e-scape.

4 e-scape methodology – phase 1

The work for project e-scape was divided - broadly - into two areas of concern. The first was with the ways in which digital technologies might be used ***to enhance learners' designing*****.** This was the priority concern of the research team at the outset, since we were determined to ensure that any digital systems introduced into the designing activity should operate as an *enhancement* to the activity - rather than a distraction or a distortion. Accordingly we worked with schools - some of which had been involved in the 'assessing design innovation' project - and explored a range of technologies with learners. These trials are outlined in section (b) below.

The second area of work concerned the *technical systems* that would need to be in place for the learners to be able to develop their solution to the task in a ***webspace*** - accessible to the learners themselves, and their teachers, and (ultimately) to examination board assessors.

a. e-scape work-parcels

As explained above in 2(c), we had in mind to start our explorations with a range of 'peripheral' digital technologies – typically hand-held – that we might use to enhance the designing activity.
Specifically, the activity we were seeking to enhance was the 6 hour 'light fantastic' activity developed for the *assessing design innovation* project.

This activity was capable of subdivision into a series of component parts, and – for the purposes of exploration with digital peripherals – we divided the activity into the following 'work-parcels'.

(i) to support learners' designing

- contextualising; task setting; handling collection
  (to contextualise and get the activity up-and-running)
- early ideas
  (to express early ideas enriching them with support from design teams)
- design-talk
  (to allow discussion to enrich the designing activity)
- photo story-line
  (to record [hourly] the evolution of modelling processes)
- design bot
  (to prompt development through questions & task-related information)
- project genie
  (to connect all the above into a coherent interface)

These work-parcels were developed iteratively. Initially we worked with a new technology - and sometimes with the supplier of a new technology - until we had developed it to the point where we felt it might be useful to support learners' designing. At that point we arranged a school trial - often just so we could see what happened. We were frequently unsure about what learners would do with the products and systems, and we were continually astonished at their ability to

assimilate the new technologies and make purposeful use of them. We outline some of these experiences in section (b) below.

The second area of work - to support teachers' assessment – was also developed into a series of work-parcels.

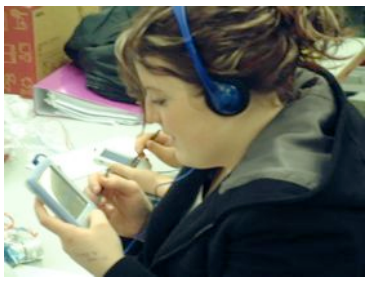
(ii) to support teachers' assessment
- collect & compile files
  (to bring together files from different hard/software systems)
- data transfer and web access
  (to make them accessible in a web-space)
- present and share for assessment
  (to present them as a coherent portfolio output for sharing/assessing)

The challenge here was somewhat different, and therefore our methodology was different. We did not focus these work-parcels towards school trials, in part because schools are just not equipped with the technology systems to do what needs doing. Our approach here was to engage in a series of meetings with leading-edge systems developers – and to a lesser extent Awarding Bodies – to discuss the possibilities for developing systems that might be able to achieve what we increasingly saw as necessary. These discussions are outlined in section (c) below.

b. school trials (Jan-May 2005)

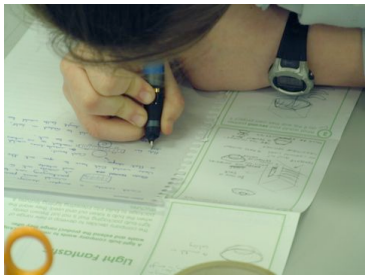
Saltash Community school
Our first school trial was in Saltash Community school in Cornwall. We worked with a group of year 12 (AS) design & technology learners, and the purpose of the trial was to explore the impact of several pieces of technology and associated communications systems;
- digital pens
- PDAs
- IR beaming to printers
- IR beaming between PDAs

Alongside these technological concerns, we were interested to explore the impact of the technology on normal working practices in design & technology. The task was the 'light fantastic' task initially developed for '*assessing design innovation'*.



A virtual handling collection of images and movie clips was created on the PDA and linked to task-setting questions. This digital enhancement was used alongside the normal 'real' handling collection that had been used in '*assessing design innovation'*

We developed a new paper workbook – based on the original form from '*assessing design innovation'*, and linked it to the use of digital pens and PDAs. At this point we were particularly exploring how these technologies impacted upon early ideas and how these ideas are shared and debated within the design group of three students.



We explored systems for beaming files between learners and also beaming to printers, so that the worksheet retained a 'real' quality through a 'paste-up' approach.

We explored 'design-talk' using DragonTalk software to capture conversation between learners about their work. This was subsequently taken further in a more focused trial with BAEd students at Goldsmiths College.

We explored the photo-story-line, using PDAs as cameras to record stages in the modelling process. Again these images were beamed to printers and used to paste-up in a 'real' booklet.

We engaged learners in peer evaluation to identify the strengths and weaknesses of their evolving work. This was done both with digital pens and PDAs. With the PDAs the comments were beamed between learners to share comments.

Principal findings from the Saltash trial

• the PDA technology was warmly received and despite the fact that it was new to all the group, learners had no difficulty at all in working out how to use it. As we point out in 1(c) above, these technologies are part of youth culture and are readily adopted. The PDAs were seen as offering new potential capability to support their design work.

• learners were less enthused by the digital pen that did not appear to offer them anything beyond a biro – and a rather fat one at that. The pen's potential for digitally storing their ideas was seen more as an advantage for teachers and assessors to review their work after the event.

• the virtual handling collection was welcomed but seen to be limited. Learners pointed out the advantage of linking the PDA to the internet for richer sources – which is possible.

• the photo story-line was very successful on the PDA – placing the decision of what to shoot and when to shoot in the hands of learners. They could then make selections and choose what to print out.

• the work with digital pens and PDAs linked seamlessly with the modelling activity.

• the design-talk was compromised by shortage of training time (to get good voice profiles) and the ambient noise in the room. Subsequent trials at Goldsmiths proved that the technology is nearly able to cope with the task – but not quite. The transcripts are not entirely reliable and multiple-voice conversations are beyond what is currently available.

• the beaming of files between learners was very easy and very warmly received – both by the learners and the teacher. It encouraged peer review and peer support for design ideas.

• beaming to printers – and the wider challenge of printing out files – requires more work to make it smooth and simple.

• the design & technology teacher was very enthusiastic about the potential – particularly of the PDA – to enrich design teaching and learning.

• the senior management of the school (head + 2 deputies) were very enthusiastic about the potential of PDAs for the classroom and more generally around the school (eg for field trips; for teachers' CPD).

Leasowes school

Our 2nd trial was at Leasowes school in Halesowen. We worked with a year 10 group who were working towards their GCSE in design & technology: textiles. The classroom was a 'normal' textiles environment – with flat top tables and a usual range of textiles technology. The task and the booklets were identical to the Saltash trial, and the focus of the trial was to see:

- whether *year 10 learners* reacted in similar ways to the year 12 group in Saltash
- whether the *larger group* of year 10 learners drew out any additional issues
- generally whether the *conclusions* drawn from the 1st trial were repeatable.



In every respect, the Leasowes trial confirmed the views we had formed as a result of the first trial. The technology was warmly received both by learners and the teacher. The PDA in particular was seen as a real step change in support for designing, and the teacher particularly reinforced the value of sharing files to encourage peer review. The integration of digital tools with 'real' tools for modelling ideas was – once again – seamless and non problematic.

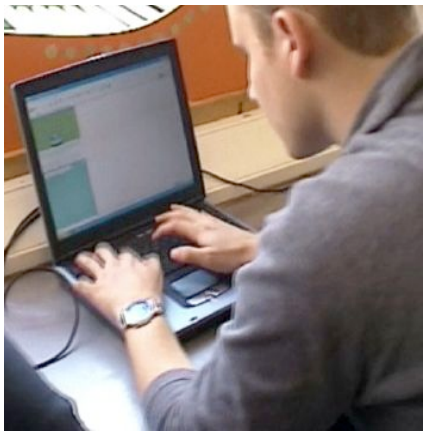
Cabot school

During our early development work we became aware (through Nesta Futurelab) of a quite new technology being developed commercially, 'bot' technology. The driving force behind this development – Phil Hall – has created a natural language system, 'Yhaken', to facilitate discussion between the public (in our case school learners) and an 'intelligent' assistant. We worked with Hall to create a *designBot*, an on-screen interactive assistant that allows learners to develop their thinking about the task by interacting with a series of questions presented by the bot. We take the view that it is the *questions* that teachers ask of learners that typically promote the greatest steps forward for their understanding, and we were interested to see whether it was possible to create this intelligent questioning through the mediation of a surrogate (robot) teacher.

To do this, an information structure was developed which consisted of some primary questions, which were followed, through varying potential answers from learners, by further question/answer dialogues to challenge their thinking and, to a lesser extent, inform it.

The information structure included twelve primary questions each of which had at least two levels of response and further questions following. It also held a bank of 'taking stock' questions to help students review their own progress and some generic, challenging questions designed to stop them in their tracks and get them to reassess the direction in which their work was proceeding.

The bot was taken to a trial with AS/A2 level design & technology students in Cabot school in Bristol. The task was the same, but the demands of the bot technology required a working environment more akin to a computer suite.



A sample dialogue:

Yhaken: [Primary question 5]: What can you do to keep the cost low?
User: use cheap materials and decrease size
Yhaken: How can you project what the cost will be?
User: total material usage and cost per metre
Yhaken: Have you thought of it being produced in high volumes?
User: yes it would be cheap to injection mould the plastic frame
Yhaken: Can you re-design to reduce the number of manufacturing operations needed?
User: yes
Yhaken: We will have to see about that ... you never know you might be on the right track here.
User: thankyou
Yhaken: Is your design using more material anywhere than it needs?
User: yes but it forms the coloured frame
Yhaken: Can you design this out?
User: not completely but could be made from cheap materials like card
Yhaken: Would it be better to leave it in? why?
User: it only acts as a protective lid whilst its packaged
Yhaken: How many items are you talking about making? One/ Under 200/ Over 200
User: over 200… mass produce
Yhaken: Why are you spending all this time on manufacturing stuff?
User: in order to develop an easily mass-produced product

This transcript is one of those that represent a decision-tree style of question/answer being engaged with. The final comment is of the 'challenging' variety mentioned earlier

Learner reactions

Learners were completely relaxed about 'conversing' with a non-human entity and entered readily into the spirit of the Bot approach. In this first contact, as might be expected, they were over-concerned for our purposes to test the limits of the system to the extent of going off-task to see what the 'bot' would do. However, the approach we used to push them back on track through interjecting assertive primary questions was shown to work effectively. They moved back and forth

between paper-based design sketches/notes and the on-screen dialogue in a completely relaxed manner [see video clips]. We were somewhat surprised by the positive-ness of the responses from students in the post-trial discussion, given the primitive state of the trial designBot. We concluded that this revealed considerable basic sympathy with the purposes and potential of the designBot.

There are however a number of conceptual and logistic problems to be tackled in integrating the bot system into our wider approach within e-scape. Conceptually, we are not clear about the extent to which the bot should be neutral questioner or an information supplier. Both are important roles played by the teacher – but they involve very different kinds of data stores and information systems. Practically, the bot will not currently operate on hand-held technology, and it's computer-suite trial is not a proper reflection of the working design & technology setting. This does not rule it out so much as focus our attention on the protocols that might need to be in place to make best use of this emerging technology.

Invicta school

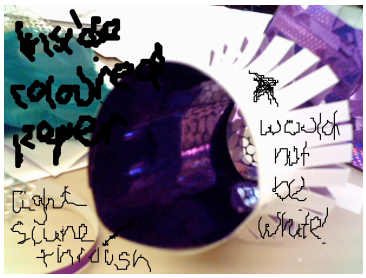
Our next trial was due to take place with a year 11 GCSE resistant materials group. Unfortunately the pressures of preparing for the examination meant it was not possible to release these learners and we worked instead with a year 12 design and technology AS group. The session took place in a small graphics studio and was set up principally to collect video evidence. Despite the powerful lights, cameras and microphones we endeavoured to run the trial as closely as possible to the standard e-scape activity format. As in the Leasowes trial we only had the pupils for a single 4 hour session.

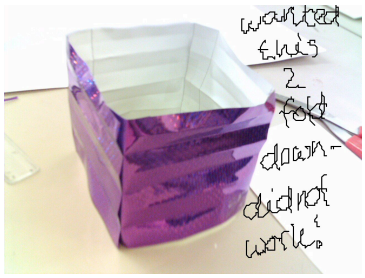
In an open question session at the start it was clear that all learners had a mobile phone; that roughly two thirds of the group had camera phones, but no-one had a 'smart' phone. Everyone new what a PDA was, but no-one had used one.

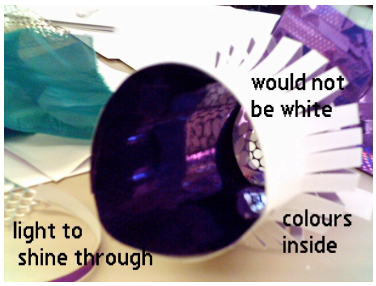
Principal findings from the Invicta trial

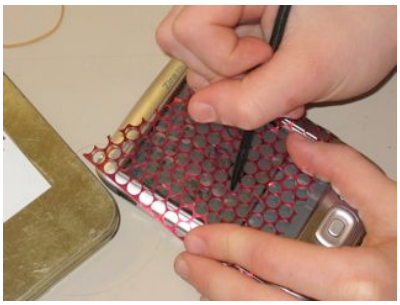
• it was clear once again that learners had no problems working out how to use the technologies. They worked independently and went beyond the research team's understanding of the tools.

• the annotating of photographs (with handwritten notes and typed text) was noted for the 1st time. Interestingly the learner in this case was developing the technique as she worked through the three examples shown here.









• acompletely new technique emerged; using sequin waste as a stencil over the PDA screen

• learners made significant use of recorded voice memos to describe the progress of their work

• faced with the exciting and unknown potential of the new PDA tools, they worked as a connected group (swarm theory) to share understanding of the PDA features. This connection extended across the whole teaching group although it was most evident in their teams.

• learners were frustrated by the quality of the PDA drawing tools we offered. Although adequate for communicating their ideas, the students all had high expectations of their own graphic skills and were concerned that the quality and resolution of their PDA notes did not reflect this. More advanced sketching software is available for the PDA, but we have deliberately not offered this in the trials as the additional functionality is more complicated to learn and use. Given the speed with which students take to these devices we should probably introduce the more complicated applications in a future trial.

• Students made significant progress in this trial, despite restricted time and the distraction of the film crew.

Pedmore primary school

Our decision to take the e-scape project down to KS2 is a reflection of the same decision made in the *'assessing design innovation*' project. There we had established that the workbook and script combination – along with the handling collection and all the other features of the activity - had worked extremely well with year 5/6 classes. Whilst some modification of the language was necessary, everything else remained the same and the response of teachers and schools was extremely positive. For e-scape however, there was an additional motive for visiting Pedmore school.

Being part of Dudley LEA, the school had taken the opportunity of acquiring hand-held technology ('Palms') a year ago, and these have since become a regular feature of classroom activities in year 6. All our previous trials had been with learners who were new to the PDA – and there was inevitably an element of fascination with 'the new'. It was – for a while – a bit of a new toy, and we needed to help learners through this stage to get them using it naturally.

Pedmore school offered us access to mature users – albeit that they were the youngest learners to try the activity. Beyond these differences – and with a somewhat redesigned workbook - the activity ran in almost exactly the same way as we had used for year 10 learners.

Learners explored the virtual handling collection in teams

They developed early ideas using digital pens

They used the PDA as a camera

They reflected on their team-mates work

A

And enjoyed beaming their thoughts to each other.

They were quite accustomed to a working environment in which digital tools rub shoulders with the general ‘detritus of manufacturing’. This table has 3 PDAs and 2 digital pens lurking. Their use – by this mature group - did not significantly change the learners approach to their design & technology task.

Principal findings from the Pedmore (KS2) trial

• The trial – along with all the associated technology – worked as successfully with KS2 learners as it had with the yr 10 and yr 12 learners. Indeed their 'maturity' with the technology made their performance with the technology – if anything - more natural. All learners completed the task and evolved a working prototype. Whilst some of our uses of the technology were new to them, they adapted to them effortlessly.

• The PDA screen was seen as constricting by these KS2 learners, and they preferred the use of the digital pens. These pens not only provided an immediate record of learners' designing, they also 'magically' remembered it all.

• Box 4, in which initial design ideas are refined into a concept for modelling, illustrated an important difference between the pens and the PDA. With the 'pens' group, their ideas were made explicit and sharable in the booklet. The PDA group however did not (or could not) print out their work and the quality of their subsequent reflection was notably poorer.

• The PDA would have been more accessible if the booklet concept had been recreated on the screen with a format that was zoom-able and responsive to the user.

• The issue of **printing** was drawn into sharp focus (we are currently using Canon Bluetooth, SiPix thermal, and PhotoSmart printers). This has been an on-going issue for us, for one might argue that it is somewhat counter to the ethic of e-portfolios. Why print them out when they exist digitally? There are several reasons for our attempts to get a hard-copy print of their work. Our decision has been based principally on the experience of the photo-story-line in the last project, where – if we gave them back to learners as thumbnail prints – they had a profound effect on their developing work. Also we cannot at the moment give learners a complete digital image of a workbook. They work only on one element at a time. So the big picture comes only from printing-out and pasting-up their work into the composite workbook.

This printing process does cause difficulties, which are evident in the photo here. Despite access to 2 laptops and 3 printers, there was inevitable queuing, which in other circumstances could create frustration and 'off-task' behaviour.

Overall, the researchers running the activity considered that the ICT in this trial did not hang together sufficiently to be really effective for this KS2 group.

• This issue raises the role of the 'design genie' which we have in mind as a device to integrate the various elements of the activity. Our initial

speculation was that the genie needs to co-ordinate the input systems based in the PDA (camera / text / sketch / voice) so that learners can operate from the genie and make choices about what they will do next.

The printing issue outlined above – along with the concept of the on-screen (zoom-able) booklet - raises the question of whether the genie might also act as an *output* device, essentially integrating all the learners work into a composite (but digital) workbook. How would learners see this on a small PDA screen? Could it be viewed at intervals through a laptop or desktop? Could it be beamed to a digital projector and thrown up on the wall? Could it be printed (as a series of A4 sheets) as a growing composite response?

These issues remain currently unresolved, but we recognise that they are central to the specification of the working prototype for phase 2.

Extended trial at Saltash Community school

In addition to undertaking the formal activity trial with the year 12 AS group at Saltash (see above), we also provided the group with a PDA each from Easter to the end of their AS project work. The purpose of the exercise from our point of view was to see what happened when learners have regular and free access to the technology. The assumption was that they would move beyond regarding them as toys – to be experimented with – and begin to use them more naturally as tools to support their designing. We also encouraged them to explore the value of using them in their other curriculum subjects and in their extra-curricular activities.

Each learner produced a report for us, focusing on their use of the PDA, and the following comments are representative of the group's reaction.

> *JP. I found the PDA fairly easy to use… uploading files onto my computer was easy. The camera (was) so convenient to record every stage of my design process, especially in the development stages. Being able to write over the top of the images was a great help … I could immediately document my ideas. I also found the sketching programme useful. A further use of the camera wa to build up a 'digital scrapbook' of inspirations.*
>
> *NK. I have used the PDA extensively for taking photos. I haven't used the sketching package. For the presentation of my folder it would be easier to pick up a pencil and design on paper.*
>
> *HC. The size makes it useful. It was useful as a digital scrapbook for me. I found it really useful being able to write a brief note over the picture to remind myself at a later stage why I took the photo in the first place. Bluetooth and the beaming feature s were the most beneficial. You can jot doen an ideabeam it to a friend and get feedback …With a PDA you wouldn't need a mobile, calculator, camera, video-recorder, games, as you have it all in one. All you need now is the internet.*
>
> *HG. I found the camera particularly useful in product design lessons as I was able to create a digital scrapbook of images for inspiration when designing and developing my*

ideas. The camera also allowed me to record experiments with different materials and put these in my coursework…. I am not keen on the layout of menus …As a whole, I feel the PDA enhanced m learning and helped me to improve my coursework, particularly for product design but also for my other subjects: ICT and English…..

DB. Very user friendly and easy to use… easy to transfer data onto your computer … beaming was good and quick

Anon. The photo facility has really good definition, and it was so useful to be able to write on the photos….the drawing was easy to use and save. BUT the instruction booklet wasn't very thorough, Graffiti 2 was difficult to use , and some teachers didn't want them used in their class. Battery life didn't seem to last long. The novelty seemed to wear off after a while and it turned out to be easier and simpler to jot things down on paper.

AK. I found it useful for taking pictures of my work and the tests that I did. It was useful for taking notes and also for beaming pictures to others within the class to give me feedback. It would be better if you didn't have to recharge it every night… and if the casings came in different colours so they don't all look the same if they are on the table together….

DH (the teacher): Having watched the students use their PDAs … students found them invaluable for recording demonstrations, experiments etc… used extensively for note taking…the camera facility was very important .. being able to record text/notes on the same image…. Unbeatable as a digital scrapbook – worth it for this alone – I have always found it difficult to encourage students to keep a scrapbook of images, quotes etc – they need no prompting with the PDA. Would be excellent if connected to the internet. Excellent in personal organisation – for staff and students.

c. systems development discussions

Quite apart from our school trials of the e-scape approach in the classroom, we have been undertaking a series of discussions with technology-based companies. The focus of these discussions has been to explore the systems by which 'hand held' technologies in the classroom might be linked (through data transfer) to web-based portfolios and subsequently viewed (remotely) for assessment by Awarding Bodies.

While there is no system that currently offers the dynamic integration and presentation features we require for this project, there are a number of e-portfolio platforms that provide the core data management systems necessary to drive the system we envisage. E-portfolio assessment for learning in design & technology requires an integrated suite of flexible process-management applications linked to open portfolio tools with embedded assessment and moderation features.

We have been in discussion with technology providers who can assist us in this task:

TAG Learning have significant experience in two of the key technology aspects of this project:
• handheld digital peripherals devices
• web based, contributory, moderated, portfolio assessment systems.

Qinetic have a useful Show-N-talk system, operate the SIMS assessment manager and a system of portable electronic school registration.

Extended system*s* operate the OneBridge system, and with the Social Services have developed a remote voice to text system based on web-enabled, hand-held (Zire) machines linked to a remote server using DragonTalk.

As part of these developments, we have also worked with **Dudley LEA** who operate hand-held systems (Zire) linked to Show-n-talk and OneBridge. and these discussions have been helpful particularly in relation to scalable implementation issues. Finally, we have had meetings with **Awarding Bodies** to explore with them the technologies that they see as emerging in their systems. Edexcel have debated with us their use of 'Paper Free' and OCR their developments with TAG Learning.

The central feature of our requirements in relation to any system that we adopt is ***connectivity****;* the capability to beam data automatically from classroom-based, hand-held technologies into pre-designated web-spaces. We have explored several possibilities (eg using USB, IR [infra-red], Bluetooth and Wireless systems) and have identified our priorities for phase 2 development. In the web-spaces we have explored a number of presentation options, including morphing, panoramas, zooming (SimpleViewer, Postcard viewer), galleries (Flickr), and albums (i-photo).

These connectivity and presentation tools need an additional feasibility study to resolve outstanding technical issues, and we anticipate that this will be undertaken during the summer, as an extension to phase 1 of the project.

5 Phase 1: findings

The work that we have outlined in section 4 has resulted in a set of findings that we will report here under the four headings from the brief:
• technological findings
• pedagogic findings
• manageability findings
• functional findings

i) technological

Concerning the extent to which existing technologies can be adapted for assessment purposes within the portfolio system as currently designed for the DfES "Assessing Design Innovation" project. This will include the applicability of other international work in this area and of any relevant system standards.

We start this section by analysing classroom hardware issues, concerning digital cameras, digital pens, digital sound and PDAs. We then look at web-based systems, including bots, e-portfolio systems and display technologies. In both cases, we describe what we have explored and how we came to decisions about what technical systems to take forward into an escape phase 2 prototype.

digital cameras

We have explored the potential of the following types of camera:

- Kodak EasyShare system (single function)
- Mobile Phone cameras (multiple function)
- PDA with built in camera (multiple function)

In the period between this project and the last, the process of printing directly from digital cameras has advanced significantly. An increasing number of manufacturers now produce 'complete' photographic systems that work without the need for a PC, including Canon, HP and Kodak. We have not made a full comparison of these systems but they all simplify the process of direct printing. It should be noted that in the drive to improve image quality some systems (i.e. Kodak) require proprietary papers and ink supplies which are significantly more expensive than standard unbranded supplies.

Our trials have reflected the Mori findings that many students already have digital cameras in their mobile phones. Pupils report that these are typically of a low resolution and not capable of capturing sufficient detail in close up to adequately record their modeling. Pupils also note that they have difficulty transferring images directly from their camera-phone to a printer.

PDAs (such as the Palm Zire 72) are now being produced with integrated cameras that have sufficient resolution (1.2 megapixels) and a balance of control features that are easy to use and sufficiently powerful to cope with the photographic demands of the 6 hour e-scape activity.

Putting pupils in control of the recording process frees teachers to concentrate on other aspects of facilitating the assessment task. It also engages pupils in the important process of selecting appropriate evidence from the wide range of photographic material they are able to collect. The integrated features of the PDA mean that it is also possible to annotate and sketch over photos to convey additional meaning.

The table in appendix Bi provides a summary of comparative features for the 3 types of camera we have considered. On balance the integrated features of the PDA outweigh the additional quality afforded by the single function digital camera, providing better quality and ease of use than the mobile phone cameras currently available to most pupils. This may be set to change in the longer term (18 months to 2 years) as the quality of cameras in mobile phones improves and more 'smart' features are included with basic handsets.

The chart in appendix Bi presents a comparative analysis – in technical terms – of the features and performance of the three options outlined above.

digital pens

We have also explored the potential of the following types of digital pen:

- Logitech iO (V1.0 and V2.0)
- Nokia (bluetooth)
- Pegasus Note Taker

To avoid the bottleneck of post-activity digitization, we wanted to develop a system in which pupils were in control and that digitisation happened continually as they worked. We considered the use of tablet PCs and a range of scanning devises, but rejected these because they all proved impractical in the context of a busy workshop environment. They were typically expensive, delicate, complicated to use and all took up far too much desktop space.

At the outset of the project we believed digital pens would provide the most effective route to digitising the notes and sketches produced by pupils during the 6 hour e-scape task.

There are 2 main categories of digital pen, some require special digital paper, such as the Logitech and Nokia, others like the Pegasus NoteTaker and the Unimatic DigiMemo do not. Although digital paper is more expensive than plain paper, it's main advantage is that it adds elements of control and functionality removing the need for buttons and menus, simplifying the process of working with the pen. Funding for this stage of the project did not allow us to develop bespoke digital paper and instead we constructed 'digital pen' workbooks by 'cutting and pasting' areas of digital paper into the existing plain paper workbook.

The table in Appendix Bii provides a summary comparison of the key features of the 3 types of digital pen we trialed. Overall the Logitech iO provided the best compromise between ease of use, features and cost and we used this pen for all the school trials.

Technically the Logitech iO pens performed well in trials and collected the digitised material we required for assessment. Provided the pens were fully charged and existing files were removed before the task, the storage and power capacity were more than adequate, and although some pupils complained that the pens were 'a bit chunky' to hold, all agreed this was not really a problem.

We did not subject the pens to extreme conditions (heat, damp, vibration) and we have not used them for extended periods of time (months), but there were no obvious problems working in a range of normal workshop situations. Assuming this pattern of robust operation continues, 'hot-swapping' and redundancy models would not be critical, and we do have the physical output from the pen to fall back on which could be re-scanned in an emergency.

To move to a full pilot implementation, beyond proof of concept, we have identified a number of additional hardware requirements. Depending on the culture of ownership required by the QCA/awarding bodies, there may be issues in terms of managing a large number of digital pens. One option would be to build an expectation that the pens belong to, and were the responsibility of, the pupils (as is the case with electronic calculators in mathematics exams) In this way the tasks of charging, clearing and downloading would be distributed across the pupil population.

There is likely to be a significant overhead to ensure all the units are properly set up if they 'belong' to the school and are only used for examination. In this case it would be necessary to develop some sort of multiple charger and docking/download system, perhaps in a modular form for groups of 10 units (as with current systems for storing and managing portable PCs).

Beyond the technical management of the hardware there is also a software requirement to provide automatic systems that securely collect, collate and manage the data from the pens, tagging and formatting it and sending it to individual pupil web workspaces.

In addition to the basic requirements above, we considered a range of other enhancements to the basic digital pen that would make them more suitable as d&t assessment tools, for example:
fingerprint recognition system
interchangeable mark-making tools
integral microphone, camera and printer

As we have 'imaged and modeled' these 'nice-to-have' future technical enhancements we realised that we were merely re-inventing a PDA and that many of our requirements were already available in products like the Palm Zire 72 and at much the same cost as a digital pen.

digital sound (speech-to-text)
In our search for an effective system to capture, edit and display pupil's 'design talk' we have considered the following technologies:
DragonTalk 'Naturally Speaking' software with head sets and a 3 way switch
Olympus (digital voice recorder)
Palm PDA (Voice recorder)
Qinetiq Social Services system

Speech to text systems have been available for a number of years and typically work by cross-referencing patterns of audio input to a library of pre-recorded voice profiles. DragonTalk is one of the most effective of these systems currently available. It achieves this by working to a more complex algorithm than other systems, and not only collects a larger library of word-sound profiles but cross references these against individual patterns of speech. This means that, with a powerful enough PC, proper profile training, good audio equipment and the right

environmental setting it is technically possible to achieve very good speech to text results with this software.

Although substantially more effective than previous systems, our requirements are still just beyond the current capabilities of DragonTalk. This is primarily because we require the system to deal dynamically with multiple voices (at least 3) in conversation. Also we are usually working in noisy and acoustically challenging workshop settings.

To overcome the problem of multiple voices, we developed a 'low-tech' system with 3 headphones connected to the PC though a 3 way switch. We created individual voice profiles for each of the pupils and orchestrated project discussions, allowing gaps of 30 seconds between contributions to give the PC time to load each new profile. While it is technically possible to create a representative transcript of a pupil's statements about their work in this way, the gap necessary between contributions to load profiles, intrudes too much on the free-flow of the conversation and makes it difficult for pupils to contribute naturally.

Over the past 6 months the performance of the DragonTalk software has been noticeably improved, but until it handles multiple profiles in conversation rather than monologue, we judge it will remain difficult to collect design discussion effectively.

An alternative to simultaneous translation would be to collect dialogue on a remote audio recording device and translate this asynchronously, returning a printed or digital transcript to pupils later in the activity, for editing or analysis (similar to the way we originally handled the digital photo storyline). The DragonTalk software provides facilities to create profiles, paired with a range of high-end digital audio recorders. Our research has shown that it is possible to create voice profiles and collect samples, using the voice recorder on the Palm Zire 72, which can successfully be transcribed remotely using DragonTalk on a PC. Although there are voice command systems available for PDAs these work on a very limited library of words and it will be at least 1 to 2 years before the processing power of a PDA is sufficient to handle natural language.

The table in appendix Biii provides a summary comparison of the key features of the 3 types of digital sound recorder we trialed. As with the camera comparison, the multi-function PDA provided the most cost effective balance of easy-to-use features, memory and sound recording quality.

PDAs (personal digital assistants)
Although there is a wide range of PDAs available, there are few that combine the features and ease of use we required for this project. Initially we identified and compared 2 models:
• Palm Zire 72
• HP i-Pac rx3715

We did not have the budget or time to make significant system comparisons. Both devices offered similar functionality and largely for reasons of cost we chose to pilot with the Palm Zire 72. Initially we purchased 4 units for internal testing and later a further 20 units for school based trials.

Design & technology workshops can be dirty and dusty environments and we were concerned to protect the PDA from damage. A heavy-duty version of Palm Zire is not currently available but there are a number of “ruggedised” containers (such as the Otterbox) that clip round the PDA to provide industrial strength protection. These solutions are expensive, typically adding £50 to the cost of the PDA, they are large and heavy, typically doubling the foot print of the PDA. It is possible to use most of the screen functions of the Zire when it is contained in the protective casing, except the camera. The level of protection afforded by these armored systems is far beyond that required in a school workshop, the cost and reduced functionality made this an unrealistic solution.

For around £20 it was possible to provide a self-adhesive, replaceable screen guard, to protect the PDA screen from scratches, and a silicon rubberised sleeve, to protect the unit from knocks and drops. We trialed with 5 units protected in this way, the rest were unprotected, none was damaged in any way during the period of the trial. While this was not a substantial test of the Palm Zire, the units are robust, and the d&t test environment proved less hazardous than we had feared.

A number of technology problems did emerge through the school trials, the most critical relate to data integrity. The main cause of data loss was power management. The memory on the Palm Zire, and almost all other PDAs, is volatile, if the batteries on the unit are allowed to run down, all data is lost. This is a major problem if you are dealing with class sets and demands that they are stored in a charging unit when not in use. The next generation of Palm PDAs (Tungsten T5) has secure flash memory to counter this problem, and beyond this, handhelds are likely to include a miniature hard drive, based on technologies now common in products like Apple’s i-pod and Palm’s own lifedrive. Other potential causes of data loss occurred through system crashes, these were infrequent and only happened on a couple of the units, and confusion over where files had been stored, use of the SD card adds another gallery and while easy to change, it is not always clear which the unit is set to use.

Direct printing from the Palms was also a problem. We explored a range of wireless options working with different printers (Canon i80, Epson 1290 and HP PS 245) using, IrDA, Bluetooth and wireless protocols. We also considered small battery powered thermal printers (Brother, SiPix) with a view to developing an integral print unit for the PDA. The weak link is the printer drivers for the Palm. It is possible to resolve this by syncing and printing from a PC, but managing printing would be far more effective if it could be achieved without the need to upload data to the PC first.

We had not intended (or budgeted) to commission any software development at this stage of the project, however in order to judge the ability of the small PDA

screen to deliver instructions and act as a contextualizing device, we commissioned Handheld Learning to build a Virtual Handling collection for the Palm. This is a rich media application, which displays, images, text, sound and video. Work on developing this mini application led to the more integrated proposal for a project management “genie”.

Data transfer from the PDA to a secure web based system is a critical aspect of the system and we have explored a number of routes to achieve this. Initially we explored the systems provided with the Palm, including; USB, IrDA, Bluetooth, SD card and wireless. It should be noted that while IrDA, Bluetooth and wireless, are all wireless systems, they operate at very different ranges. IrDA data transfer can only operate across short separation (10cm), Bluetooth can cope with transfer around a room (10m) and wireless would typically operate across a site (100m). While it was fairly straightforward to setup and use these systems individually, it was clear that managing class sets of data would require additional data management tools. This prompted us to investigate commercial systems for managing networks of remote PDAs through web-based systems in particular OneBridge, from Extended Systems. From our conversations with Extended Systems and the Dudley LEA team it is clear that it is technically possible to achieve the integration of the PDA and web-based systems we require. However, a more detailed technical feasibility study is required to specify and cost this accurately.

The table in appendix Biv provides a summary comparison of the key features of the 2 types of PDA we trialed.

Web based Chatter bots

We explored the potential of creating a conversational ‘chatterbot’ interface to support pupils working on the 6hr design task. We worked with Elzware, who have developed a product called Yhaken that currently provides natural language customer support on a number of commercial websites (i.e. the ikea.com help centre).

The Yhaken system provides a conversational backbone and we developed an information structure for aspects of the d&t activity that was layered over the top of this. The system is delivered through a standard web interface and with some modification it would be possible to deliver this to the web client on a PDA. In the school trials pupils accessed the ‘design bot’ using a PC. The ‘design bot’ gently pushed questions to the pupils in order to nudge then towards creative responses. These conversations are collected providing a record for analysis and assessment.

The technology functioned well and pupils were happy to converse with it. The critical factor here is to model and develop the necessary conversational structures, which may be a more appropriate focus for phase 3 when we have more experience of the way in which pupils respond to the digitally augmented task.

Web based e-portfolio systems

The MAPS (managed assessment portfolio system) from TAG Learning is currently providing web based ICT portfolio assessment facilities to over 60,000 pupils. The system is hosted on a remote server and provides critical aspects of technical functionality such as; user management, secure access, remote set up, file storage, tagging, back up, virus protection, help and support.

In partnership with TAG we have identified the technical requirements necessary to manage a web-based portfolio for the 6hr design & technology task. Many of the basic portfolio functions are available from the existing MAPS modules. Critically there are a number of additional elements that we need to resolve in the next phase of the project:
data transfer (see PDA section above): we need an effective link between the classroom-based PDA collection device and the web-based portfolio system.
formative integration of the process of completing the task with the process of assessing outcomes. The MAPS system separates these and we need to bring them together.
procedurally convincing and visually compelling presentation of the content of the portfolio. We must provide an effective file presentation, as well as file management system.

Display technologies

Assessing design & technology capability onscreen from portfolios of digital evidence is a new endeavour. While there are currently no systems available to achieve this, the team has considered a range of display technologies that could help to augment the assessment process.

From analysis of the assessment processes carried out with ‘real’ scripts by markers on previous projects, the 2 key display functions would appear to be comparison and scale.

Throughout the marking process, assessors’ attention continually zooms in and out of scripts, initially framing an overview and then focusing in to check out individual aspects of performance in more detail. Having made judgments on an individual aspect of performance, markers consolidate this by making complex comparisons between other aspects of work in the same script, as well as comparing it to similar aspects of performance in other pupils from the same group and from exemplars provided by the team.

Initially we considered the different ways in which components of pupils’ work could be animated on screen in order to make better comparisons:
panorama (a line of images stitched together in a long strip)
morphing (a stack of images dissolving into each other one after another)

The effect of these animated sequences was visually compelling and helped to convey the story of the learners growing ideas. We could also see ways in which they could be used to make comparisons between responses. Zooming in and out

was more difficult to resolve, as there were no obvious reference points from which to control the zoom.

We subsequently looked to existing zooming interfaces for ideas on how this might be implemented in a web-based system. Increasingly visually rich websites are employing 'Flash' animated components to provide compelling animated effects. It is increasingly possible to explore previously flat (html) linear galleries of images through more dynamic systems that support and display a more fluid range of lateral paths.

10 by10 simple viewer
http://www.tenbyten.org/10x10.html
(zoom in and out of images one at a time from a dynamic grid)

postcard viewer
http://www.airtightinteractive.com/projects/flickr_postcard_browser/app/
(zoom in and stay zoomed to explore)

yugop
http://amaztype.tha.jp/
(organize, distribute and zoom)

flicker
http://www.airtightinteractive.com/projects/related_tag_browser/app/
(distribute, zoom and cross link)

Internet connection speed is an issue in effectively delivering these zooming and comparing effects. We will resolve these issues in the technical feasibility study proposed for the next phase of the project.

ii) pedagogic

Concerning the extent to which the use (for assessment purposes) of such a system can support and enrich the learning experience of design & technology

In this area, the findings from the trials have been quite unequivocal. It is clear that the use of peripheral digital tools of the kind we have been using in our trials offer the opportunity for considerable enhancement of the teaching and learning environment. The following examples illustrate some of this potential;

- the use of the PDA as a device on which preliminary design ideas can be generated is extended hugely by the potential for 'beaming' work between students. This addresses the 'teamwork' imperative for design & technology and the PDA offers in particular the potential for a team of learners to operate on different layers of screen. One student initiates an idea, the next can supplement or critique the idea on an overlay screen so that the supplementary drawings/notes appear drawn on to the original. They can however be viewed as a separate layer – teasing out the contributions of individuals.

• the PDA enables learners to build a digital scrap book to enrich projects that are underway. This comment emerged from teacher and learner comments. The learners were interested but not greatly impressed by the virtual handling collection that we had built into the PDAs. They wanted to get onto the internet to enrich the collection of images and ideas. The teachers pointed out the difficulty of making this happen when learners operate on paper, and were delighted at the attitude shift when learners were empowered with PDAs. The facility to snap, store and subsequently select images that relate to the project is very important in this setting.

• the facility also to take regular photos of emerging models and prototypes was welcomed by learners and teachers alike. It is not that they ***couldn't*** take them previously, it is rather that the process of doing so with a PDA is so easy and quick, and the results can so readily be catalogued. Moreover they can be annotated with overwritten notes, and can be drawn on – either direct onto the image or (again) onto an overlay screen that has the potential of being separated from the image. These functionalities dramatically extend the range of approaches that teachers can introduce, particularly in relation to the teaching of designing, which Ofsted reports continually identify as the greatest weakness in design and technology.

• the design talk feature has been widely welcomed by teachers who are keen to accentuate the peer-reflection / peer-review potential of the system. Whilst it does not fully work at this point, the voice recognition (speech-text) technology is just close enough to see how it might work in an ideal world. If we can make this work within the design genie, it would be a radical step forward in terms of student learning. Being able to participate in a discussion - get an instant read-out (or print-out) of it – to overwork this with highlighter pens to indicate real priorities for action – would represent a learning tool that currently just does not exist.

• in the last 5 years, the use of lap-top and desk-top technologies has been expanding in design & technology particularly as CAD and CAM systems have become somewhat more commonplace. However, for two reasons, departments struggle to bring these technologies into the mainstream. First they require a very substantial investment before a group of students (say 24) can simultaneously be accommodated with the facility. In the (typical) absence this level of investment, teachers are required to regard the technology as an optional extra in their main programmes of study. If however the funds are available to equip a whole group, then the problem arises of where to put them. This typically involves taking a studio/workshop out of commission and re-creating it as a computer suite. The e-scape trials that we have described above, change the nature of the debate with regard to access to digital technologies. Hand-held devices (eg PDAs) are relatively cheap (£200) and do not dominate space as desk-top machines do. PDAs do not have the screen space for running CAD tools, but we have shown how many other tools are available and can greatly enrich the teaching and learning of design & technology.

iii) manageable

Concerning issues of making such assessments do-able in 'normal' d&t classrooms / studios / workshops

- the training / cpd implications for teachers and schools
- the scalability of the system (including security issues) for national implementation

The issue of manageability have been at the forefront of our thinking in e-scape, and it has several dimensions.

• is the hardware/software manageable for learners?

We were surprised at the speed with which learner groups assimilated the technologies we offered them. The digital pens and the PDAs were – in almost every case – completely new to learners, and their approach to this situation can best be described as a 'swarm' response, using distributed intelligence. Particularly with the PDA – which has a wide range of capabilities – one learner would be shown or discover a new facility and in a matter of minutes it had been shared around the group so that all knew it. It is also clear that mobile phone technologies are ubiquitous and well understood by this age group, and there is a cultural familiarity with the use of such hand-held devices. It has to be said that some of the software tools on the PDA were not particularly helpful and were not used, and the trials have been useful in showing us the kinds of software that will be most valuable for the 6hr activity. An additional problem was created by the fact that the software tools were only available as free-standing applications. Learners needed to open the applications, log into them and only then get on with their work. This process would be dramatically streamlined and simplified through the use of the design genie, which we plan to use to manage and integrate all the available tools.

* does the hardware raise theft and loss issues ?

We have been aware of the potential for theft and loss of equipment, particularly as it is highly portable (and pocketable). We should report at the outset that we placed 13 PDAs in a trial school for three months. Every one came back and none was damaged in any way. However in reflecting on the issue, there appear to be three different ways of thinking about the matter. First, whilst computer costs are in the £1,000s, PDAs are currently approx £150, and within a year will probably be less than £100. Second, students all have their own mobile phones, and in a year or two these will no doubt become 'smart' phones that are - in effect - PDAs. The school does not feel obliged to manage the ownership and maintenance of these, since they are personal property. Third, there are school subjects that demand the use of calculators – and even scientific calculators. Schools do usually have policies for this, but the assumption is typically that learners are responsible for having their own. When they become critical to learners' participation in formal examinations, schools sometimes have sets of them available. Between these policy areas, we suspect that it would not be impossible to arrive at a policy that would work for schools and be acceptable to learners and their parents. And underlying this policy would be the assumption – as a starting point – that learners would have (and be responsible for) their own PDA.

• is the activity manageable on hand-held technologies?
The e-scape design & technology activity began life located in an A4 booklet that opens out to an A2 sheet of paper. The PDA screen, which we believe will be at the heart of the e-scape system, is of the order of 60mmx75mm. There is clearly an issue of how the scale of work that is possible on the booklet can be accommodated on such a small unit. Part of the solution lies in the fact that the booklet is in any event sub-divided into small sections – many of which are about the size of the PDA screen. So, for example, box 1,2&3 are all about PDA screen sized. This does not get around the problem that seeing (and working on) one box at a time is not the same as seeing the whole booklet. The ability to scan the whole emerging piece of work is an important part of keeping a procedural grip on it, and there is no reason to believe that this can be done when only one box at a time is in view. Accordingly, we propose that the prototype will have a number of features that allow learners to zoom in and out, enabling them at one point to operate within a single box and then zooming out to scan across the whole (see the discussion in 5(i) above). The 'zoomed-out' scale of screen would of course be too small to read directly – but it might be projected onto a surface, or it might be printed out at selected points during the activity. We speculate that three A4 print outs of progressive parts of the activity might build up into a different form of booklet that would achieve the purpose of keeping the whole of learners' emerging work accessible to them.

• can teachers manage the activity ?
There is little evidence from the trials to inform this issue. In all cases, the research team has run the trials, and the involvement of the class teacher has been an optional extra. However, as with the 'assessing design innovation' project, the activity will be scripted for the teacher/administrator, and the design genie – built into the PDA – will serve the same integrating and coherence function as the booklet has served before. We therefore see no reason why the activity should not be capable of being run by teachers assuming they have sufficient familiarity with the system. In the past this familiarity has been achieved by operating as co-administrator with one of the research team. This, along with some technical familiarising with the hardware and software should be sufficient to enable teachers to operate the system. The degree of training and familiarity that is required will be an issue to be explored when the phase 2 prototype is up-and-running.

• is the outcome of learners' work assessable ?
There are several ways of looking at this problem; is the work reviewable/assessable by the learner, and/or by the teacher, and/or by the Awarding Body? We anticipate that the outcome of the activity will exist in two forms. It will be progressively printed out – probably on 3 A4 pages that link together to form a continuous storyline for the activity. And it will exist in a web-space. The most obvious approach to assessment would be to assume that (at the school end of the process) the paper booklet will be the principal unit for assessment, whilst (at the Awarding Body end of the process) the web-space will be the source. It would be quite possible for the teacher and/or the learner also to use the web-space, but we are aware of the limitations that might exist in schools

with access to screens that are both big enough to scan the whole of the work and that allow web access. So the activity might proceed as follows:
the learner works through the activity
the work is automatically and continuously logged into a web-space
at points in the activity, the learner prints out progressive parts of a booklet
at the end of the activity the teacher can collect all the booklets into a single box-file
each learners' work is also review-able in the web-space
it is a matter of preference which source the teacher uses for assessment
when the teacher is confident that the work is complete, it can be approved for AB access
at which point the AB can be empowered to log into the web-space and review the work.

Our trials have demonstrated that print-outs of the work that has been done with PDA/digital pen (ie the paper-based evidence for assessment) appear comparable with those that arise from the paper-based booklet. The same processes of assessment could therefore be conducted. We are not at this point able to comment on the assessability of web-space work, since we have not yet created the design genie that would facilitate this. However, we believe that the assessment process will be manageable, and indeed may be easier, since the assessor will be able to call up instant comparisons with exemplar pieces.

• is the system scalable for national assessment purposes?
There is little that we can say on this matter as a result of the phase 1 trials. We see no reason why the system should not to be capable of application in any school that chose to do it, provided they had the technology in place and all the resources that facilitate the activity. The web-space end of the system is infinitely extendable so there is equally no reason to believe that the system has scalability problems. In so far as one can anticipate scalability problems from the work done so far, they will probably lie in
a school's access to technological kit
learners' familiarity with that kit
teachers preparedness to engage with the digital activity

The 1st is a resource question – that in terms of the '06 pilot would be dealt with as a provision paid for by the research. The 2nd and 3rd questions centre on issues of training, and they would be key research questions for the pilot. How familiar is it necessary for learners to be with the kit? How much training do teachers need to be comfortable with the system?

iv) functional

Concerning the factors that an assessment system based on such technologies needs to address;
• the reliability & validity of assessments in this form
• the comparability of data from such e-assessments in d&t with non e-assessments

There is less for us to report under this heading than under the other three. Using the three big issues that are subsumed here – validity, reliability, and comparability – we are in a position to comment principally on the first.

Validity takes several forms, but for the purposes of our work may be summarised as the extent to which the activity, as we have designed it, represents 'good' design & technology. A standard approach to the problem of deciding on validity, is to appoint an expert panel of design & technology specialists, and invite them to make a judgement as to whether the activity is – in their view – a good example or model of design & technology. In relation to this procedure, there are three kinds of evidence that may be considered.

First, the activity is a direct development from the booklet-based activity that was initially developed in the previous project; 'assessing design innovation'. The assessment activities that were devised in that project originated with the research team but were then shared with the principal subject officers of the four Awarding Bodies. These Bodies were sufficiently impressed with the work to each 'volunteer' two of their principal design & technology moderators to work with us in developing more activities of the same kind. These then formed the basis of the extended pilot, and were warmly received in the 8 schools in which they were administered. We should note that the eight resulting activities spanned the complete spectrum of design & technology, from product design to textiles, food, systems and control, and graphic products. We take the view that the four Awarding Bodies (their subject officers and principal moderators) can be regarded as an expert panel of consultants. The activities were not merely judged by them but developed with their direct collaboration, and we would therefore assert that these activities had high validity as representing good models of design & technology practice.

Second, the e-scape activities have been developed directly from these former activities. We have conducted one trial of the 6hr kind that was a complete reflection of the previous project (even using one of the same tasks), and we have additionally conducted a series of shorter trial activities to test parts of the process. All of these trials have been done in booklets that – whilst being modifications of the original – are recognisably the same format. They have a number of identical features:

- handling collection
- box 1,2,3
- red pen
- modelling
- photo story line
- team review

etc etc

We would argue that there is prima facie evidence that the resulting activities might be regarded as good models of design & technology merely through association with their predecessors.

We recognise however that this judgement is somewhat clouded by the innovation process itself. In the e-scape format, the changes result in no pencil and paper sketching of the kind that is absolutely characteristic of design & technology. Rather there is (eg) PDA screen sketching and this is (somewhat later) printed out into a booklet. This is certainly not design & technology as it might conventionally be seen.

However, the third arm of our validity case lies with the teachers who have undertaken these e-scape activities. These teachers have been clear in their view that whilst the tools have changed (from analogue to digital) and that this results in a very different form of representation of designing, the activity itself remains true to design & technology. We would draw attention in particular to the recorded interview from Saltash Community School, where the teacher concerned is this year's "outstanding teacher of the year" awarded by the DATA professional association. As a leading practitioner in the field, he is enthusiastic about the activity itself and the effects it has on the learners in his school. We would suggest that this is further evidence of the validity of our trial activities.

Reliability is a more straightforward concept, and may be thought of as repeatability, in the sense of whether an assessment made by one teacher (using our system) is repeatable by another teacher. Do they arrive at the same result? This may also be extended to examine repeatability between those concerned with the process. Do teachers in the classroom make the same judgements as Awarding Body officers given the same evidence?

We currently have no data to inform these questions. The trials that we have undertaken have resulted in learner outputs that are assessable. These outputs (the pasted-up booklets) have been used by the research team to ensure that the processes of assessment that we used in the last project could be used again with these new booklets. However, the number of learners involved is tiny, approx 100, and in each school we were trying something different. So in reality there are several non-comparable samples of approx 20. Phase 1 of the e-scape project has been deliberately exploratory. Accordingly we have no data to comment on the matter of reliability of assessments, either between teachers or between teachers and Awarding Body officers. These are matters that should properly be embraced within the pilot study that we will run in Sept 06, based on the e-scape prototype system that we shall build in phase 2 of the project.

The comparability question is a straightforward challenge, asking whether a learner achieves a similar level of performance when assessed through the e-scape system as he or she does when assessed through a paper-based equivalent activity.

Once again this is a matter for the pilot study in Sept 06. We recognise the importance of the matter, since the e-scape system will change subtely the skills that are traditionally associated with designing. There is still sketching – but not as it traditionally might be represented. In phase 1 of this project, we have not been in

a position to collect data to inform this comparability question, and we note that it is a priority matter for the phase 2 pilot study.

These findings; technical, pedagogic. manageable and functional – taken together – have informed the development of a specification for the prototype system that we propose to build as phase 2 of this project. Furthermore, having built the prototype, we plan to run a pilot study in September of 2006, and this study will equally be informed by the findings from phase 1.

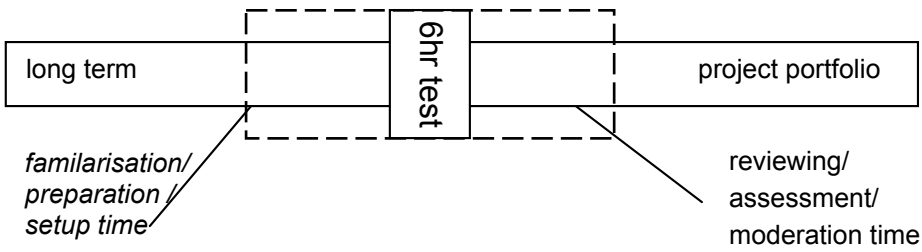
6. specification for the e-scape system

The purpose of the e-scape phase 2 prototype is to create a system where the individual components, explored in principle in phase 1 of the project (and judged to support d&t capability) are built into a working prototype. The elements must work together sufficiently well in the field to ensure we can put enough learners through the system to collect sufficient data to answer key research questions for the various stake holders, such that they are confident to move forward to a commercial, scalable implementation in phase 3.

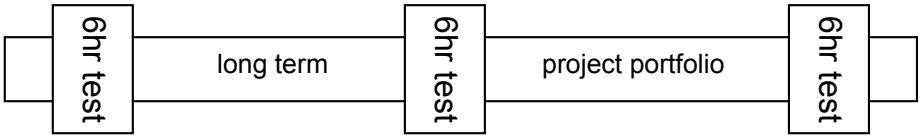
Throughout this process, data integrity and security will be a particularly important issue. Specifically we need to minimise the possibility of data loss during the 6hr activity where learners are working on potentially volatile handheld systems. We also need to ensure that the interfaces we develop (both on and between the technologies) are intuitive and easy for teachers (and learners) to understand and operate. We are using the outline specification below to guide our development towards phase 2. The elements of it are not all 'deliverables' in a contractual sense, but are included here to indicate the range of technical and user issues that we believe will have to be dealt with to ensure that the system works smoothly. As we work through phase 2, we can anticipate that the relative importance of the various elements will become clearer, and we might therefore expect that some will be fore-grounded while others move into a background.

a) defining the remit for phase 2

We do not have the time or resource to create a universal, cross-platform, fully functioning e-portfolioing system. However, a useful frame of reference to consider this matter is a continuum of 'closed test' to 'open portfolio', and on this continuum, the phase 2 e-scape pilot sits somewhere in the middle, straddling the 2 extremes. The extent to which we extend the reach of the pilot either way along the continuum will be governed by the need to prepare and familiarise teachers and learners, and integrate the new approaches into awarding body systems.



We need to demonstrate that the activities work for teachers and learners. This means we need to provide sufficient web-based access for them before the task (to prepare for it) and after the task (to consolidate and mark it). Our work on the previous 'innovating assessment' project suggested that a 6 hour paper-based assessment task could fit into a design & technology course of study in a number of ways:
- individually at the start, end or middle of a course
- at regular intervals during a course



It is important that we explore how digital enhancement effects and illuminates the 'fuzzy interface' we have described between a **formal test** and more **informal project work**. One strand of piloting should look to answer questions about the effect of different programmes of testing using the basic 6hour framework: eg concerning single and/or multiple tests and different tasks.

We also need to study the interaction between the qualities and capabilities of mobile pocket PDAs and desktop web workspaces.
• how much detail is it possible to condense on to a small screen?
• s it possible to expand/mitigate this with 'zooming' interfaces?
• how can PDA and PC systems be used together in a single working environment?

In phase 2 we will develop a working system with sufficient online access and web functionality before and after the digitally enhanced 6 hour activity to ensure that teachers, learners and Awarding Bodies:
• are prepared to run the activities effectively
• are supported during the activity
• are trained and supported to make and moderate assessments of learners output
• can transfer data electronically into selected Awarding Body systems.

b) defining the technology

The pilot in phase 2 centres on making the elements so far trialled (the phase 1 work-parcels) work together. The system we develop should model as closely as possible what has been shown to work for design & technology in the paper-based environment. No changes should be made for purely technical reasons. If changes are explored this should be for reasons of pedagogy or manageability. As far as possible we will avoid making demands on school ICT systems, over which we have little or no control. We will focus on clarifying basic connectivity requirements for schools running this type of activity. Where possible the demanding aspects of the system will be hosted and managed on a remote web-based server system.

At the end of phase 2 we will provide;
• a working prototype design & technology e-scape system, comprising linked components to set up, run, review and mark learners work.
• a comprehensive design document detailing data schema, administration schema (QCA, ABs, school, classroom), user experience routes and mock-ups for proposed key screens for interface of the system
• a detailed specification of how this system can be implemented across different technology platforms, in different school and workshop settings, and with different awarding bodies.

c) **key aspects of the system**

During the first phase of the project we have explored, developed and trialled a range of individual digital enhancements to the original paper based framework for assessing innovative capability in design & technology. In order to consolidate these into a working system, we have described below the following system requirements:

1) access before (to prepare for the test)
2) setting up
3) 6 hour activity
4) data integrity/transfer
5) access after the test (to develop, mark and moderate)

1) access before the test activity (How learners and teachers prepare for the task?)
- 1.1 preparation
  - how do we get teachers, learners and Awarding Bodies ready to do the task?
  - familiarity with systems (hardware, connectivity, software)
  - familiarity with activity (format, instructions, resources, outcomes)
  - ground work for activity (preparation, seen/unseen,)
- 1.2 teacher and awarding body support
  - guidelines/instructions
  - training (workshop, webcam, telephone, e-mail,...)
  - support

2) system set up for 6 hour test activity
- 2.1 hardware must:
  - meet the technical specification for the test
  - be fully charged
  - have enough storage space
  - check for existing stored data
  - check print resources (connections, ink, paper)
  - ensure hot swap kit (broken or lost - bits and wholes)
- 2.2 data requirements:
  - pre-load pupil data (names, UPN , UCI)
  - load task-specific materials (instructions, resources)
  - set tags for awarding body (school, class, learners, date, time, task, etc..)
  - set permissions for access (pupils, teachers, exam officer, etc)
  - terms & conditions (for each group and critical actions)
- 2.3 connectivity
  - connection check (for all the devices - PDAs, PCs, printers)

links between pupils (restrict to team or whole group or wider?)
links to web workspaces (learners, teachers, exam officer)

2.4 teacher support
tutorial documents (how to use the system, how to run the test)
telephone / email / interactive support
Training sessions and workshops
- on using the system
- on running the tests
Online forum to discuss issues
Updatable FAQs...

3) 6 hour test activity

3.1 security
personal log in
pairing PDAs, learners, workspaces
data transfer (password encryption)

3.2 instructions
to teacher/administrator
for learners

3.3 resources
contextualising
handling collections
virtual on-screen booklet

3.4 tools (with rules for how they can be used)
notes
sketches
voice recorder
camera (still/video)

3.5 e-scape genie/timeline (intuitive interface to support and drive the activity)
to stimulate (instructions, handling collections, resources)
to collect (a data bucket for everything recorded)
to select (identify and upload key items to tell story of idea)

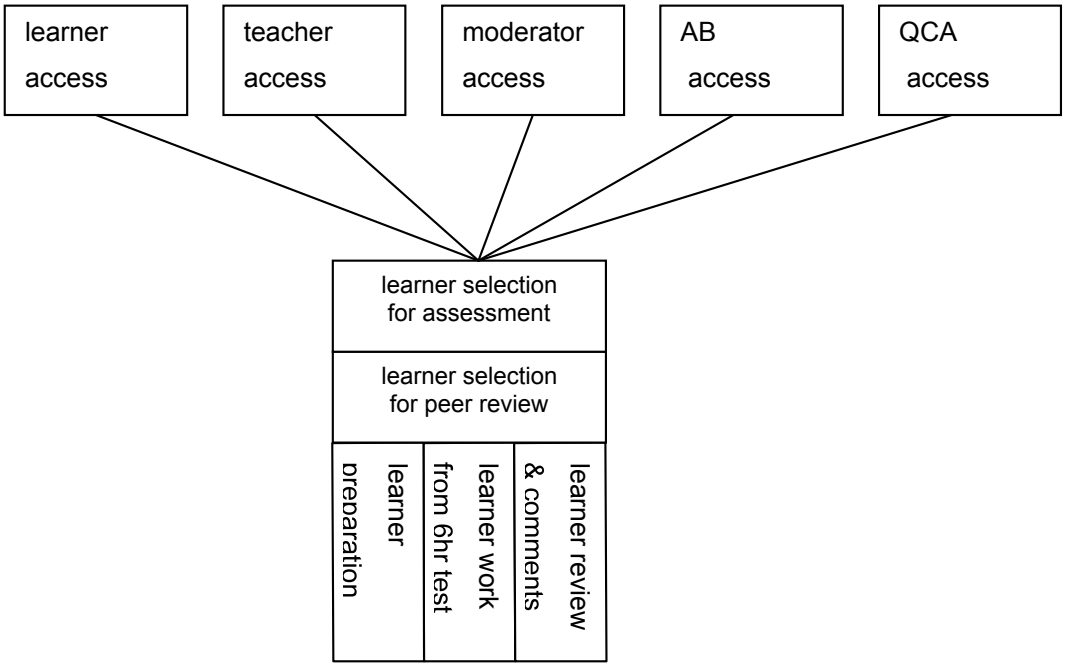
3.6 reviewing options for viewing what has been done ***as it's being done***;
to output / print
on PDA
on PC (pupil workspace in web-based e-portfolio)
data-projected

3.7 data integrity
passwords and permissions
terms and conditions
transfer during test (automatic push to SD card, server, ...)
backup during test (always on 'push', regular syncing, print out)
virus protection

4) data transfer

4.1 data schematic (formalise clear picture of what data goes where)
4.2 learner to learner (PDA to PDA)
4.3 learners to teacher

4.4 PDA to central server (via school internet link)
4.5 teacher to moderator (from school/centre e-portfolio to AB e-portfolio)
4.6 awarding body to QCA



5) access after the test activity

5.1 log in determines view and tools available

learner sees own and group work with tools to review and annotate
teacher sees all learner work and tools to comment and assess
moderator sees selected learner work and teacher comments
(need to clarify levels of access for each group)

5.2 learner web-based workspace

learner d&t home page (navigation, look and feel, personalise aspects
post test components/features (add/modify comment on project story-line)
self assess (against criteria in pupil speak)
peer review (own and others)

5.3 teacher web-based workspace

teacher home page
components/features

- messaging system for annotating pupil work
- marking tools (exemplars, marking rubrics)
- submission tools
- telephone / email / online support

5.4 moderator web-based workspace

moderator home page
components/features

- view marking rank order
- select sample to view
- moderate and indicate recommended adjustments
- indicate when moderation for a centre completed

- output moderation adjustment forms
- output tally charts of samples moderated
- build personal moderation portfolio

5.5 awarding body web-based workspace

awarding body home page (create and assign moderator)

components/features

- principal moderators review moderator's adjustment
- decide on centres where adjustments are required
- decide on centres where re-marking is required
- decide on centres where test must be re-run.

5.6 QCA workspace (national stats/usage)

QCA home page

components/features

6) administration roles

6.1 school system administrator (examinations officer?)

input/update/manage learner data

auditing and reporting centre resource requirements

identifying centre training and support requirements

validating pupil/school responses

6.2 awarding body administrator

managing centre/school data

posting and monitoring resources for specific tests

reporting, managing and meeting training and support requirements

input/update/manage moderator data

validating awarding body responses

7) Collecting Evidence/feedback

7.1 during trials

digital/paper questionnaires

online/face-to-face interviews / vivas

feedback seminars/brainstorming sessions

informal message boards

7.2 as part of the published system

system use, data flow, other metrics

formal questionnaires

free text comment/ideas box

informal message boards

Standards

The e-learning, e-portfolio, e-assessment territory is informed by many sets of technical standards (some international) that seek to 'standardise' that territory – either in terms of systems input, user protocols, and/or output processes. Wherever possible and appropriate we will take due note of these standards. However it should be noted that the challenge for the e-scape phase 2 prototype is to create something that does not yet exist anywhere in the world, and accordingly there are no standards that will entirely circumscribe our work. We would expect the e-scape project to inform international standards as much as be led by them.

7. emerging research questions for phase 2

The development of the prototype system in phase 2 of the e-scape project will be based on the specification outlined in section 6 above, and following its development, a school pilot will be conducted to explore the efficacy and the effects of the e-scape, e-portfolio, e-assessment system. A number of research questions will inform this work.

In the construction of the prototype system we will be guided principally by ***technical*** questions, concerning for example;

- the connectivity between hand-held devices in the classroom and web-spaces
- the possibility of pre-defining this web-space so as to construct a virtual booklet
- the security of access to this virtual booklet through user-names / passwords

However, the process of developing the prototype will also be informed by pedagogic, manageability and functional assessment questions, for example:
pedagogic: how will the construction and appearance of the virtual booklet impact upon the questions and sub-activities that need to be built into the activity ? How will the design genie impact on practice in the classroom? How might the progressive-print-out process for a 'real' booklet relate to the virtual booklet?

manageability: how often will the PDA need to be sync-ed to the web-space ? How long does the process take and can a class of (say) 24 learners manage this process simultaneously? Are learners able to manage their work in the web-space?

functional: how does the assessment process change when viewing the virtual booklet as opposed to the real one?

These four kinds of questions will be constantly in play throughout phase 2 of the e-scape project, but the ***technical*** ones will be pre-eminent during the construction of the prototype. However, as we move into the pilot study in September 2006, the priorities switch, and functional assessment questions move to the top of the agenda. We will be very much concerned with issues such as:

- the ability of the system to enable reliable judgements to be made of learners' work
- the differences in assessment when based on 'real' booklets and virtual ones
- the ability of Awarding Bodies to moderate and assure comparability

But alongside and interacting with these priority questions within the pilot, will be associated pedagogic, manageability and technical questions, for example:
pedagogic: how is the designing activity changed by the system? What backwash effects would teachers anticipate in relation to KS3 practices?

manageability: how much cpd/training do teachers need to prepare for this mode of assessment? What are the costs of implementing this system – for the school and for the Awarding Bodies?

technical: how robust is the system? What is involved (and who is responsible) for managing and maintaining the system?

Appendix A work parcel pages

key project focuses and findings

- Photo story-line
- Virtual handling collection
- Digitising early ideas
- Design ‘talk’
- Design ‘chatter bot’
- Design ‘genie’

e-scape portfolio assessment in design and technology

Photo story-line

What is it?

- a visual trace of a student's developing solution
- an integral part of the portfolio / booklet
- every hour for 6 hours
- a digital photo
- immediately printed and given back as a thumbnail

Why do we think it is important?

- initially a means of keeping assessment evidence
- but it transformed students attitudes to the task
- focused and energised their modelling

How did we do it?

- with an ordinary digital camera (Kodak)
- images stored on a digital chip
- that could be put directly into a mini printer
- i.e. no computer necessary

Who did we do it with?

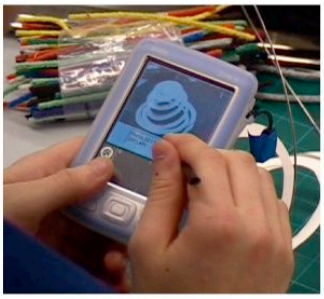
- initially with experimental school groups
- then in every school trial (approx 400 students)
- yr5/6, and yr 10, 11, and 12

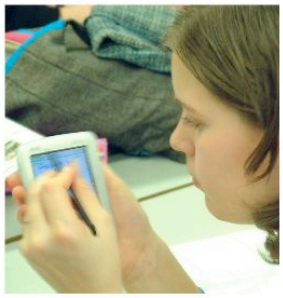
The PDA as a camera

- the in-built camera facility
- transfers photo responsibility to students
- many images can be stored
- selections can be made
- to illustrate the modelling story

Editorial power to students

- images can be ordered
- and annotated
- and animated or morphed
- into a personalised story





Virtual handling collection

What is it?
- digital enhancement for 'inspiration collections'
- view using handheld device
- full range of media including video, audio and animation

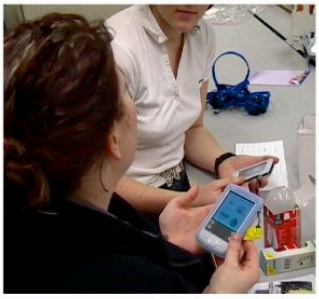
Why do we think it is important?
- available to students to revisit throughout the activity
- provide standardised prompts and questions
- draw attention to particular features
- extend collections to include wide range of resources

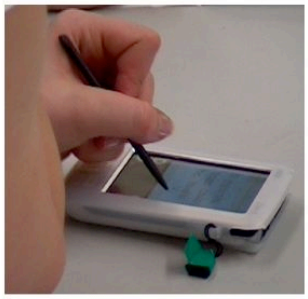
How did we do it?
- identified appropriate subset of resources
- explored potential authoring applications (PDF, html)
- constructed prototype in rich media PDA database (Kinoma)

Who did we do it with?
- initially with researchers and students
- then in e-scape school trials (approx 100 students)
- yr6, and yr10, and yr12

Outcomes
- all students instantly familiar with digital information
- despite access through unfamiliar technology

Next steps
- web enabled system allowing deeper interrogation
- integrated search facility
- link to and from 'Design bot system'
- need to integrate into activity management system





e-scape portfolio assessment in design and technology

Digitising early ideas

What is it?

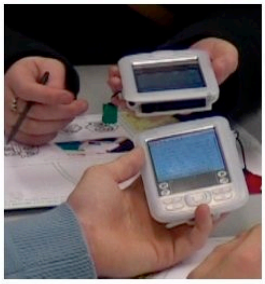
- a system to digitally record sketches and notes
- available, anywhere anytime in the activity
- robust and easy to use (teachers and students)
- with facilities to share information

Why do we think it is important?

- provides cost effective digital assessment evidence
- back up, store , manage and share pupil data
- can be made available through web systems
- improves students' d&t experience

How did we do it?

- initially with digital pens (Logitec iO, Nokia, Pegasus)
- using modified workbooks (digital paper and post-its)
- later with handheld PDA (Palm Zire 72)
- range of applications (Memo, Sketchy, TealPaint)



Who did we do it with?

- initially with researchers and students
- then in e-scape school trials (approx 100 students)
- yr6, and yr10, and yr12

The PDA as a notebook

- same writing space as the booklet
- now - freehand sketching, text, typed text,
- future - virtual keyboard SMS

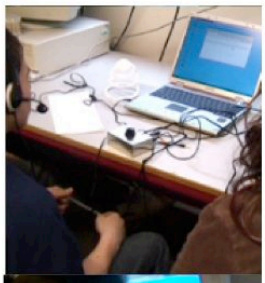
The power of sharing between students

- new medium of communication (chatting with images)
- primary desire to connect with each other
- clear trail of evidence
- completely intuitive

Design 'talk'

What is it?

- talking is a critical aspect of effective design
- designers use talk to work out what things are for
- we still know very little about how talking works in design

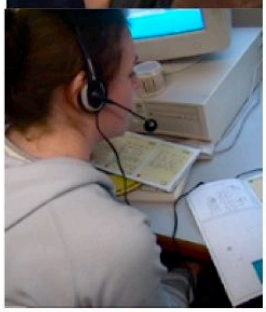


Why do we think it is important?

- teachers agree that talking is a key discriminating aspect
- talking is currently difficult to capture

How did we do it?

- create individual voice profiles (DragonTalk Naturally Speaking)
- wire up students for sound (headsets through 3 –way switcher)
- orchestrate structured discussion



Who did we do it with?

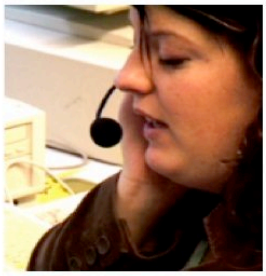
- initially with Yr 12 students
- then researchers and students

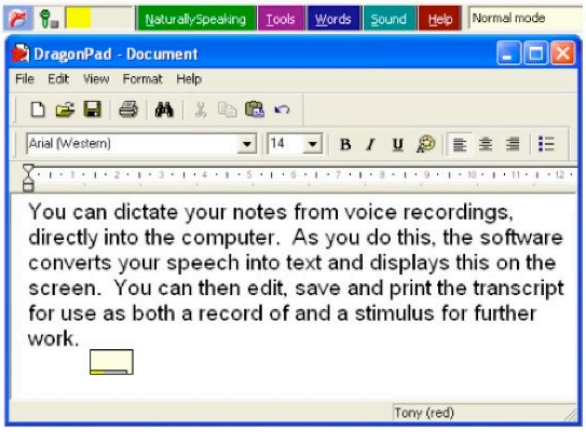
Outcomes

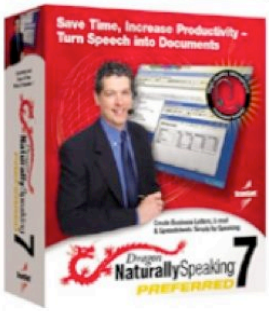
- voice recognition profile for a range of students
- transcripts of students' comments on their work
- video of the process in action

Next steps

- technology is close but not quite there
- remote system to collect and transpose voice via PDA
- even if we can't make it work yet everyone agrees this is important







Design 'chatter bot'

What is it?

- on-screen interactive assistant
- prompt reflection on the progress and quality of their work
- conversational interface using natural language

Why do we think it is important?

- standardise teacher interventions (surrogate teacher)
- introduce pre-qualifiers to random interventions (digital dice)

How did we do it?

- using existing chatter-bot technology (Yhaken)
- with established natural language system
- push technology

Who did we do it with?

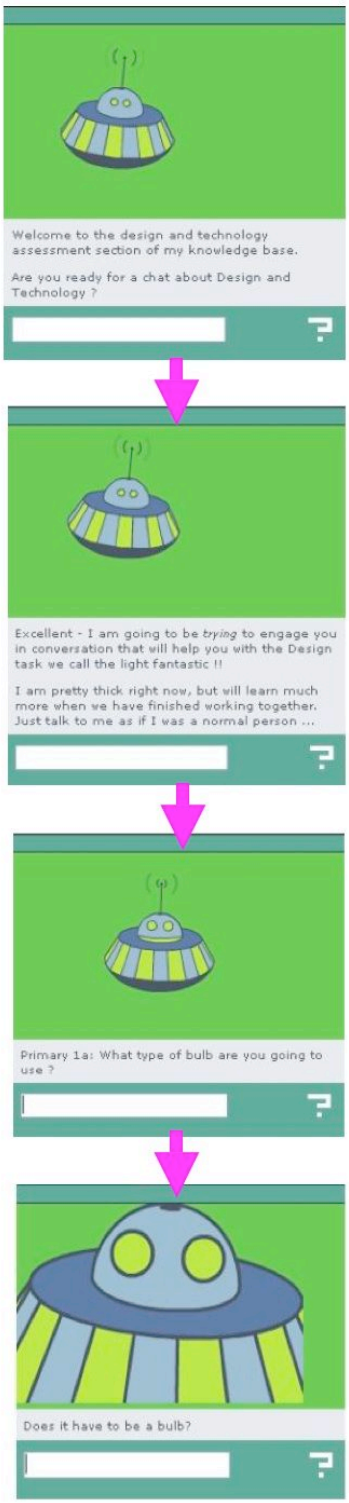
- Elzware (developers of the Yhaken chatter- bot)
- Futurelab (incubator funding)
- Y12 students and researchers

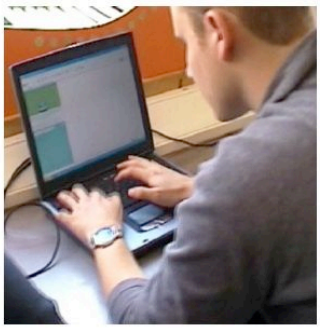
Outcomes

- students quite happy to suspend disbelief and 'talk' to a computer
- most 'play' with the bot when they first encounter it
- pushing key questions
- database of key questions and 4 levels of branching responses
- transcripts of student conversations

Next steps

- extend database of questions and responces
- extend trial to KS3 and 4





Design 'genie'

What is it?

- d&t project management system for handheld PDAs
- available to every student any-where any-time
- a virtual sketchbook, the 'glue' that holds everything together

Why do we think it is important?

- allows students to review and look ahead to all the activity resources
- presents and manages all the PDA tools available to the students
- automatically collects, tags and displays all the files created by the students
- provides a filtering system for the students to identify the key aspects and milestones of their work
- encourages students to reflect and comment on the evidence they have collected
- ties together all the digital elements of the project

Appendix B equipment comparison tables

	Kodak Easy Share CX7330	**typical phone camera**	**Palm Zire 72**
Cost	£90	pupil owned	£150 - £190
	still + video	voice + camera	multi-function
Ease of use			
- on/off, framing, taking	2 clicks	variable	2 clicks
- automatic setup (focus, light level, flash)	wide scope	limited	OK (no flash)
- manual control (resolution, light, zoom)	wide range	limited	OK (no zoom)
- reviewing, saving, selecting, deleting	good	limited	good
Image storage			
- image quality	high (3.1 MP)	low(640x480)	med (1.2 MP)
- file format (jpg)	jpg	jpg	jpg
- capacity	16MB + card	variable	24MB + card
- backup	SD card	limited	SD card
Transfer (backup/direct printing)			
- USB dock	yes	no	yes
- Compact Flash/SD card	yes	no	yes
- Wireless (IR, Bluetooth)	no	yes	yes
Battery life			
- time between charging	2 AA batteries	variable	5 hrs (full use)
- time to charge	variable	variable	less than 2hrs
Additional features			
- date/time stamp	yes	with SMS	yes
- annotating photos	no	with SMS	yes
- sketching on photos	no	no	yes

table Bi digital camera comparisons

	Logitech iO2	**Nokia**	**Pagasus**
Cost	£180	£190	£150
Special paper	yes	yes	any paper
Ease of use			
- on/off	instant on	instant on	11 x buttons
- in use	tick boxes	tick boxes	complex menu
- ergonomics	poor	moderate	good
- software	moderate	moderate	moderate
Data storage			
- capacity (A4 pages)	40	50	50
- file format	jpg, giff, txt,	jpg, giff, txt,	jpg, giff, txt,
Transfer (backup)			
- USB dock	yes	yes	yes
- wireless (Bluetooth)	no	yes	no
Software			
- manage, modify, convert	yes	yes	yes
- use multiple colours	yes	yes	no
- convert handwriting to text	yes	yes	yes
Battery life			
- time between charging	3 hrs (full use)	2 hrs (Bluetooth)	2 AAA batteries
- time to charge	2 hrs	2 hrs	variable
Additional features	password	password	mini screen

table Bii digital pen comparisons

	SoundMorpher	**Olympus DS330**	**Palm Zire 72**
Cost	£24	£150	£150 - £190
Ease of use			
- on/off record	simple	moderate	simple
- playback search	limited	moderate	simple
- headphones	yes	yes	yes
- external mic	no	yes	no
Data storage			
- capacity (recording time)	4 mins	2 hrs 35 mins	24MB + card
- file format	wav	DSS, wav	wav
Transfer (backup)			
- audio out	yes	yes	yes
- USB dock	no	yes	yes
- wireless (Bluetooth)	no	no	yes
Battery life			
- time between charging	3 AAA batteries	12hrs	5 hrs (full use)
- time to charge	variable	variable	less than 2hrs

table Biii digital voice recorder comparisons

	HP i-PAQ rx3715	**Palm Zire 72**
Cost	£290	£190
Features		
- camera	1.2 MP with video	1.2 MP with video
- sound recording	yes	yes
- note taking	yes	yes
- operating system	Windows mobile 2003 ed 2	Palm OS 5.2.8
- screen	240 x 320 TFT	320 x 320 TFT
Data storage		
- RAM/ROM	128 MB	32 MB, 16 MB
- card slot	SD/MMC/SDIO up to 1GB	SD/SDIO up to 1GB
Transfer (backup)		
- audio out	yes	yes
- USB dock	yes	yes
- IrDA	yes	yes
- Bluetooth	yes	yes
- wireless	yes	SD adaptor
Battery life		
- time between charging	up to 12hrs (light use)	5 hrs (full use)
- time to charge	less than 2hrs	less than 2hrs

table Biv PDA feature comparisons

Appendix C references

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