# Intelligent Pens, Paper and Ink

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## Abstract

PaperWorks is an EU project  concerned with providing distinctive ways of interleaving paper documents with digital materials. The project focuses on developing a core technology for interlinking established content in paper and electronic domains. This is demonstrated through a robust application where a non-obtrusive pattern on the paper allows users to interrelate content with associated digital information. PaperWorks involves innovative developments in the production of novel substrates, inks, reading devices and the integration of software and communication resources as well as requiring an adaptable information architecture. PaperWorks draws on innovative research to develop support for authoring information and associated links.

Edexcel / Pearson Education have now been working with this project group for 18 months and are developing a method of linking these technologies to both summative and formative assessment processes. The project also involves an analysis of the development and capture of creative and problem solving processes.

Edexcel/ Pearson also have a keen interest in developing the links between assessment and learning and through this project are able to demonstrate a variety of potential opportunities that the technology can provide to foster and nurture these links.

## Project Partners and Acknowledgements

## Background

Despite the wide-ranging recognition that paper remains a pervasive resource for human conduct and collaboration, there has been uncertain progress in developing technologies to bridge the paper digital divide. This paper revisits the long-standing interest in Computer Supported Co-operative Work (CSCW) with paper, and looks at ways which will enable people to create affinities between material documents and digital resources. An example of this could be enhancing an educational book associated with a television series. Such a book could be augmented to enable the reader to point to pictures or text on the page and gain associated information - video clips and the like - on a workstation, a PDA or television set. settings.
Studies in this area have discovered over and over again one remarkable fact - despite the pervasiveness of new technologies, accompanied in many cases by management's attempt to reshape traditional practice and procedure i.e. the paperless office, paper remained and remains a critical feature of work and collaboration. Many of the examples are well known; - the paper timetable in London Underground ; the traditional medical record in primary health care; ( fig. 1) the tickets in financial dealing rooms ; the documents reviewed by lawyers; and so on. Fig 1.
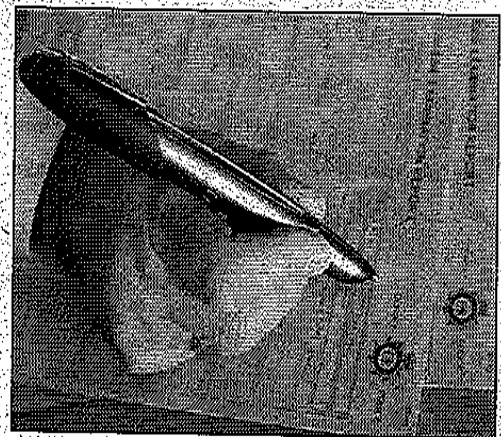
Paper allows for collaboration because it is mobile, portable between different spaces and regions; it can not only be relocated and juxtaposed with other objects and artefacts, but is micro-mobile, it can be positioned in delicate ways to support mutual access and collaboration. Paper is annotated in *ad hoc* and contingent ways; people can recognise those annotations, track their development and often recognise who has done what. Paper retains a persistent form and preserves the layout and character of art work that is produced on its surface; it can be pictured, memorised, and navigated, even scanned, with ease.

These characteristics and many more not only support complex individual activities but provide a firm foundation to many forms of collaboration, be it synchronous or asynchronous, co-located or distributed. Paper has provided a critical resource to enable people to use technologies even conventional information systems. Paper is used with, and alongside, digital technologies and people spend much time and effort creating, sustaining and transforming the relationship between paper documents and digital resources. Students, teachers, journalists and the like edit text on paper and transpose those corrections to digital copy, architects modify paper plans and integrate those changes in the CAD system, administrators litter their workstations with reminders, diary notes and the like, and booking clerks laboriously write down the details of your travel arrangements before trying to enter the information into a system. Paper is not just an independent resource that somehow has continued to survive despite attempts to remove it, but rather is an integral feature of using new technologies. It is somewhat surprising that such relatively little effort has been devoted to enhance the relationship between paper and the digital. If, as seems possible, we can begin to provide people with the ability to access and create links between, for example, paper documents and digital content then this capability has profound implications for the production and presentation of content. Publishers and some types of broadcasters who produce textual materials alongside programmes would need to rethink and reconfigure the ways in which they structure and present content, and in turn this would have an important impact on the organisational arrangements and practices that currently underlie these industries.

# Spy pen for police

A JAMES BOND-style pen that will write off police paperwork and put more bobbies back on the beat is being used for the first time. Officers in Dorset say the £100 Magicomm works like a normal pen but has a 5mm camera beneath the nib that records what they write. The data is sent via mobile phone to a central computer where it is converted into text. The process will stop officers having to return to their station to type information from dozens of forms on to a computer. Form-filling takes up a third of an officer's working day.

**Pen cuts down paperwork**   Picture: BNPS

## Aims and Objectives of the PaperWorks Project

PaperWorks is concerned with developing distinctive technologies for interleaving paper documents with digital materials. The project aims to provide people with new forms of functionality in everyday environments through seemingly mundane artefacts.  The project aims to:

- develop robust, reliable and usable solutions that enable people to access, create and use links between paper and digital resources;
- identify and support applications that enable professional and lay content providers to exploit augmented paper solutions;
- develop innovative hardware and software technologies and techniques that integrate different approaches to augmenting paper.
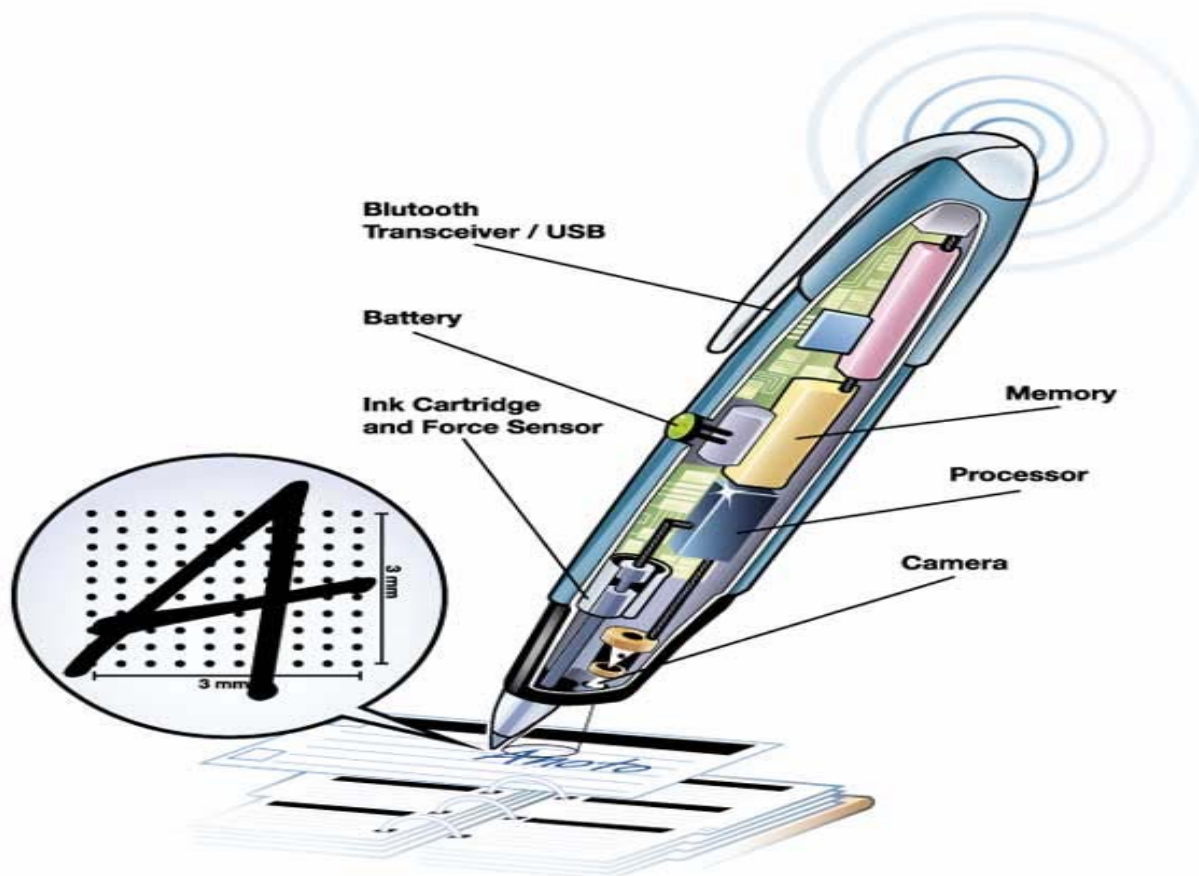
# Description of Work

The project undertakes a range of technical, design and empirical activities in order to develop a robust augmented paper solution that could be integrated with a published product..  The project is developing:
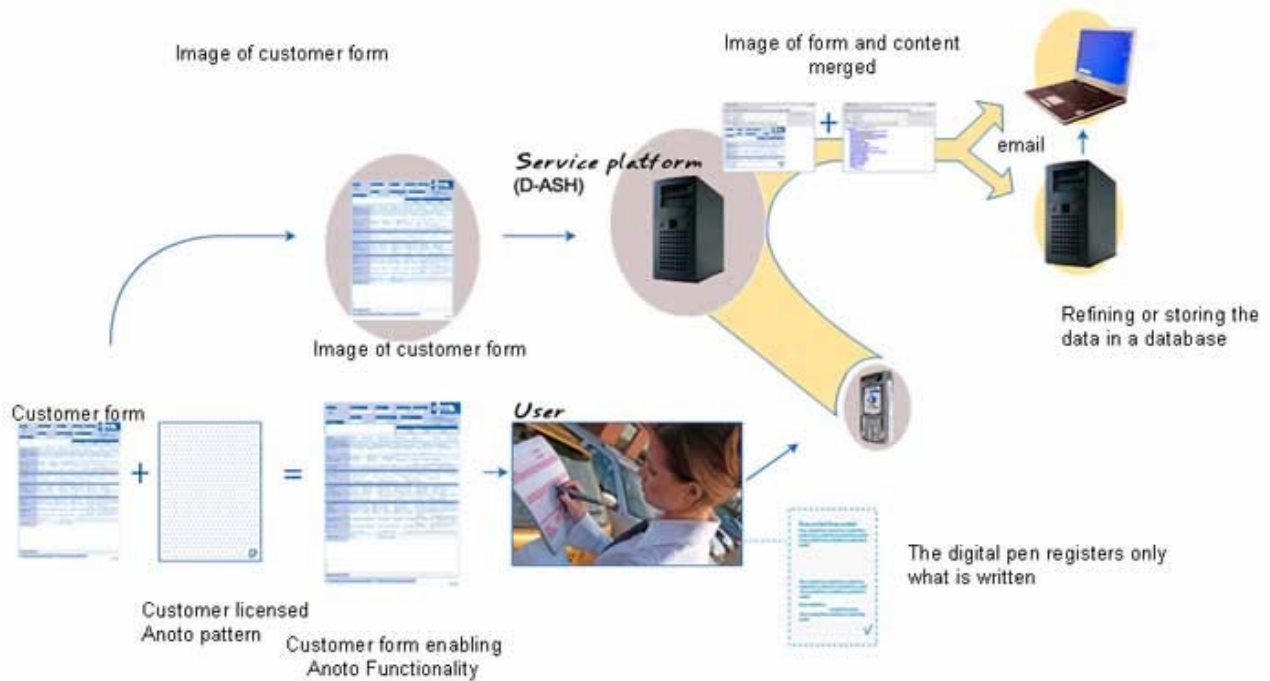
1    a technique for detecting locations on a paper substrate that is robust and reliable than existing solutions using simple electronic sensing; a substrate and artwork where the pattern is invisible for practical purposes;

2    an information architecture that can support a range of different media; a range of interaction styles and a range of different kinds of linking mechanisms;

3    interaction styles that are consistent with properties of the media and make apparent the augmented capabilities;

4    authoring tools that support professional and bespoke publishers;

5    ways of integrating augmented reading with augmented writing and approaches for integrating active paper graphics  to provide feedback and additional resources to support augmented reading and writing;

6    methods for designing, developing and assessing augmented paper applications considering the needs and requirements of content providers and 'end users'.
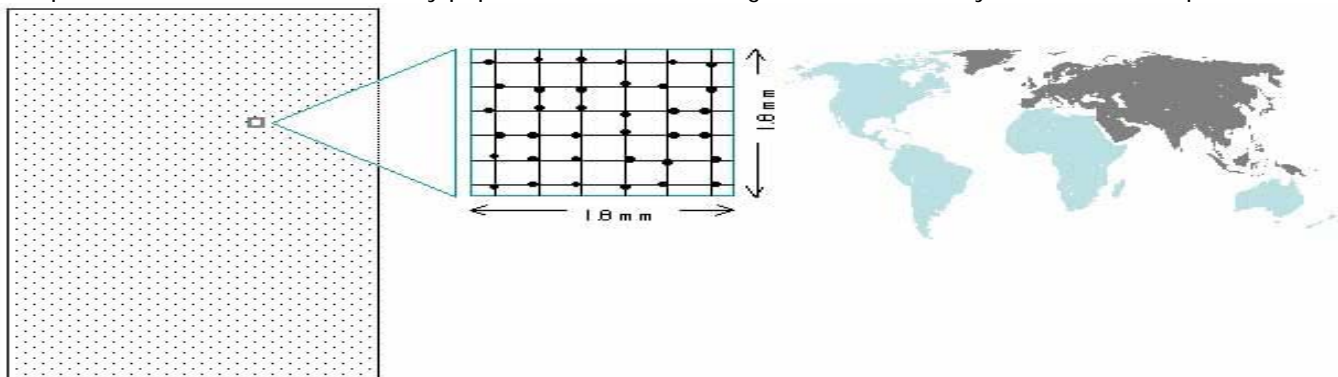
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## Anoto Technology

One way of detecting positions on paper has been developed by Anoto which forms the basis of commercially available products such as Nokia's Digital Pen, Logitech's Io and Sony Ericsson's Chatpen. These devices capture handwriting, so notes can be sent via e-mail or downloaded to a computer and then converted to text. The Anoto technology relies on an almost invisible pattern of pre-printed dots on the paper and sophisticated electronics built into the pen. Instead of scanning and recognizing single lines of text, the Anoto pen uses a built-in CCD camera to view the infrared-absorbing dots, each of which is slightly misplaced from a square array. Images are recorded and analysed in real time to give up to 100 x-y positions per second, which is fast enough and of sufficient resolution to capture a good representation of all handwriting.

When using digital pen and paper enabling Anoto functionality, a tiny camera in the pen registers the pen's movement across the grid surface on the paper and stores it as series of map coordinates. These coordinates correspond to the exact location of the page you're writing on.

The Anoto pattern is a single unique pattern that if printed out would cover the whole of Europe & Asia. It is a series of small dots printed on an invisible grid.

The pattern can be embedded in any paper document and images such as form layouts can be overprinted.



Once graphical image are received they can then be converted to ASCII text and transmitted in data files most commonly in XML format.

*The paperworks project is supporting a variety of applications but this paper looks specifically at an experimental assessment and collaboration application*

## The Assessment Application- Anoto Technology and Collaborative Assessment

### The Original Study

The Technology Education Research Unit (TERU) at Goldsmiths College- London have developed a system of assessment that measures and rewards design innovators working in collaboration.

### Collaboration

There is a mass of literature concerning the importance of team-work both in teaching/learning situations and in designing situations. But for assessment purposes, there is a pathological fear of using the massive support that it provides to students because of the association with 'cheating' and also being able to separate out and award credit to the individual contribution to the team.

The Technology Education Research Unit were determined to overcome this problem and arrived at a solution involving groups of three students . The grouping was designed explicitly to support and enrich the *individual* work of the team members. It is this individual work that is then assessed.

# The Assessment Activity Description

The assessment activity is developed through the subject GCSE Design and Technology, looking at the assessment of ; generation ideas; development of ideas and proof of concept.
The booklet which records the students work is used in two phases;
1 during the project exam / design task, by students
2 during assessment, by the assessors
The students work together in groups of three with a head designer and two co-designers, each with their own design booklet.

The assessment activity was developed as a 6-7 hour task: two consecutive mornings of 3 to 3.5 hours. In that time, students start with a task and work through from an initial concept to the development of a prototype solution – a 'proving' model to show that their ideas will work. The whole 7 hours is run by the teacher – following a script that choreographs the activity through a series of sub-tasks - each of which is designed to promote evidence of students' thinking in relation to their ideas.



These 'steps' in the process all operate in designated spaces in a booklet;
1. read the task to the group and establish what is involved
2. 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.
3. put down first ideas in a designated box in the booklet
4. working in groups of 3, students swap their booklets and each team-mate adds ideas to the original
5. team-mates swap again so that each team member has the ideas of the other two members
6. booklets return to their 'owner' and team members discuss the ideas generated
7. the teacher introduces the modelling/resource kit that can be used throughout the 2 mornings
8. students develop their ideas in the booklet - and/or through modelling with the resources
9. students stop to reflect on the *user* of the end product and on the *context* of use, before continuing with development
10. at intervals, students are asked to pause and row a dice - with questions on each face. The questions focus on procedural understanding e.g. "how would you ideas change if you had to make 100?' and students answer the questions in their booklet
11. photographs are used at approx 1 hr intervals to develop a *visual story line* to illustrate the evolution of models & prototypes
12. at the end of the 1st morning, students – and their team members reflect on the strengths and weaknesses of their evolving ideas
13. the 2nd morning starts with a celebration of the work emerging from day 1. This is based on post-it labels that highlight students' thoughts about the qualities in their ideas
14. further prototype development
15. regular hourly photos and pauses for reflective thought on strengths and weaknesses
16. final team reflections, when (in turn) team members review each others' ideas and progress
17. individually, students then 'fast-forward' their idea illustrating what the product will look like when completely finished and set-up in context
18. students finally review their work from start to finish.

## Some Conclusions from the Original Study

Detailed conclusions can be found in the report ( reference 1)
An assessment activity was created that was very tightly controlled by the administrator; using the script, the booklet, the handling collection, the modelling resources etc.. But learners' reaction to it, reported, that they feel a great sense of freedom in developing 'their own' ideas and making 'their own' products. The procedural framework which was encapsulated by the format of the booklet is the secret to this. It is rich in support systems, creating fertile ground for learners' independent ideas to take root and flourish and provided the ideal vehicle for group interaction and interchange

## Team-work

At the end of each activity students were asked to complete an evaluation form which identified all the components of the activity (e.g. the photo story-line). On a Likert scale of 4-1 (very helpful, helpful, unhelpful, very unhelpful) students were asked to identify their reaction to the components. For girls, it is clear that the most popular features of the activity are the *group generation of ideas*, the *photo story-line* and the use of *modelling resources* (all approx 3.5 on the Likert scale*)*, and these three are shortly followed by *the group evaluation of ideas* (Likert 3.4). (Likert 3.5). For boys, six features rank at almost the same level of helpful/very helpful. The *handling collection*, the *group generation of ideas*, the *photo story-line*, the *modelling resources, the booklet space for sketches/notes,* and *helping the group with ideas* (all approx Likert 3.2*)*.

## This Collaborative Assessment Study Adapted for use with Anoto Technology

## This is work in progress

The students are each given a booklet printed on Anoto paper ,a modelling kit, PDAs, PCs, printer, large screen display and Anoto pens

The Anoto booklets were carefully designed to unfold throughout the activity ensuring students always have sight of the instructions for the sub task they are currently working on and the work they have just completed. There are 22 steps which are all represented by a frame to be filled in by the student(s) during the assessment period. All frames contain hints for how to go on with the design process and how to reflect on your own work. There are different kinds of frames:
a. Text frames with lines to write text on.
b. Sketching frames with open space for sketching and writing
c. Post-it frames for sticking on Post-it notes
d. Picture frames for sticking on digital pictures of models and material made during the project
e. Combined frames for combining ideas, notes, sketches, dimensions, design decisions
There are a series of symbols ( tools ) which can be used to allow for certain actions to take place or objects to be linked. They appear as buttons on the paper

The Anoto pen will recognise the underlying co-ordinates where these symbols are printed and will trigger the appropriate action to take place i.e. replay video, snap to grid to construct a net shape of a 3 dimensional image etc

## Scenario 1: Enhanced Design Work

This scenario focuses on how the students use the booklet during the project.

The students have an Anoto booklet, an Anoto pen for each student, a PDA/computer (possibly projected on a wall display), a digital (video-)camera, a printer, a variety of modelling material for the assignment.
The booklets are folded – only showing the design task
The student's name, group number and group member's names are pre-printed. The groups are formed and registered beforehand.
It is the Anoto paper which is registered to an individual student or a space on the paper. The Anoto pens in this experiment were anonymous and can be used by any student.



## Frame1,2,3,4



These frames are designed to be worked on by the 2 other partners in the group. The Anoto pattern in this part of the booklet is registered individually to the other two partners
What would the first partner do if this was their own project?
What would the second partner do if this was their own project?. At any stage it will be possible to open one or more frames to be displayed on a large screen display. This allows a selection of frames for a group discussion, at any time during the process

## Frame 5



Frame 5 extends the collaborative element by allowing the design partners to, not only write down their comments in a particular frame, but to write or sketch their comments and ideas directly on the sketching surface
Tying identity to the paper, and printing out frame 5 for partners to comment or add sketching ideas, makes it possible for partners to comment and sketch on top of head designer's sketches without disturbing the original drawings
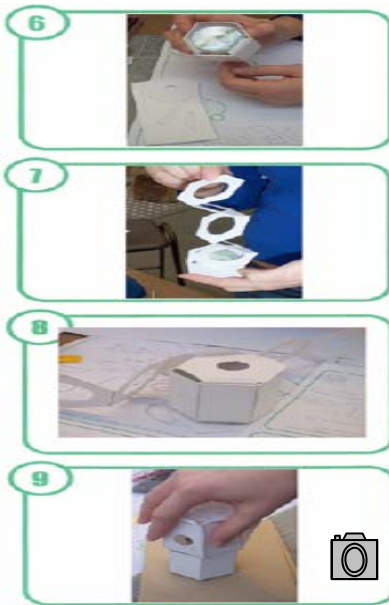This can be done by having a printing function; printing out the sketch frame for the partners
The assessor it will be possible to trace who did what, even though pens are used randomly

▶ Print to partner 1
▶ Print to partner 2
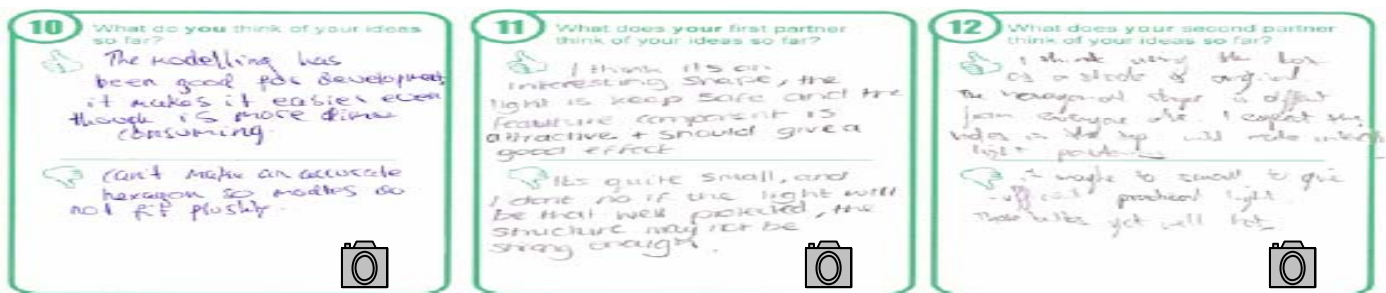
## Frames 6,7,8,9



By sketching with the Anoto pen connected to a computer the hand-drawn sketches in frame 5 can be augmented by 'snapping' the shapes into precise shapes by drawing tools connected to the Anoto pen. This will be useful to build the physical model. In this example the 6-sided polygon can be drawn with precise sides and angles, and in the preferred dimensions. It will be easy to change the size. Linking can be made to inspirational ideas like shapes from nature, industrial products, and the human body by simply adding a link to a website or linking to a document on the computer. The sketches can be displayed on the wall in order to enhance collaborative design decisions. The model can be transformed to a 3D model. After refining the model from paper sketch to 3D in the computer, the computer model can be 'unfolded' and printed on cardboard in order to make a cardboard prototype.

▶ Snap to grid

In frame 6-9 the first cardboard based prototype is documented by picture-links to short videos showing different aspects of the design concept. Photo series of early model (day 1)
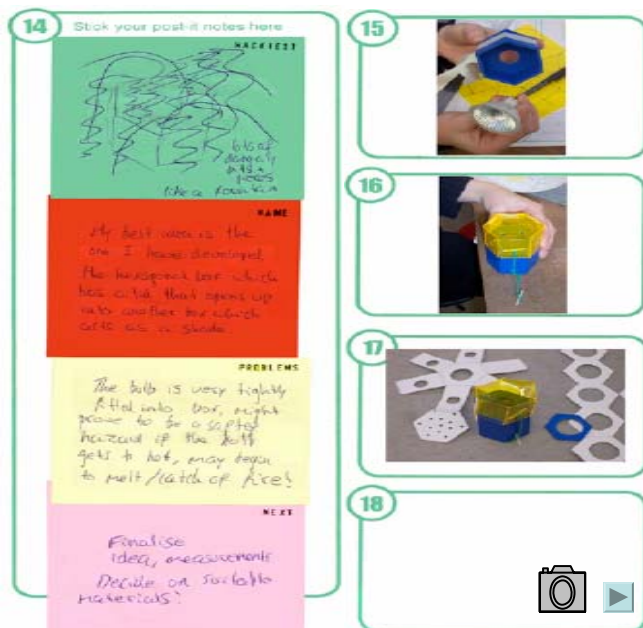- – The photos can be video clips
- – It is possible to initiate the video clip by touching the play button with Anoto pen

## Frames 10,11,12



Frame 10-12 lets the students discuss aspects of the design concept so far, by writing down positive and negative opinions from each of the three students. i.e. What do you think of your ideas so far? (10), What does your first partner think of your ideas? (11), What does your second partner think of your ideas? (12)
One or more particular frames can be display on a large screen, for group discussions

## Frames 14 -22



Frame 14 is for sticking on Post-it notes with keywords summarizing the design sessions of the day among all groups. This is first done on large paper and 'recorded' by the Anoto-pen. Each Post-it sticker contains links to each individual project.

Frames 15 -18 contains information on how a model is built in materials which are representative of the final design solution. This part is documented in frame 15-17 (18) by picture links to short videos. The pictures contain links from different parts of the prototype to material specifications, samples of the material and other designs made in the same material.

Photos from day two. The photos can be video clips which can be activated by touching the play button with Anoto pen.

Frames 19 and 20 contains partners 1 and 2's thoughts on the design ideas so far.

Frame 21 contains the 'head' designer's own thoughts on the work.

Frame 22 contains possible obstacles for the future

## Future Work; Scenario 2: Enhanced Assessment

This is the next phase of this study, the work is already in progress, but at time of writing this paper specific results are as yet to be collected and analysed. This scenario focuses on how the examiner can be supported in the assessment of the work. The system is being designed to allow the assessor to track:

a.   design decisions
b.   distribution of work and decisions among students
c.   external resources (links made during the design work)
d.   speed of work
e.   process
f.   interaction and collaboration amongst the students

There are several work parcels supporting the assessment process. The first will look at compiling & collating files for assessment . Files can be layered to allow synchronous and asynchronous work to be viewed. It will analyse the physical process of assessor interaction with a variety of digital information i.e. zooming in and out and  multiple screen viewing. The second will look at the assessment tools with the development of the assessment tool box i.e. instant access to assessment criteria, archive materials, benchmark  standards and exemplar matches

## Conclusion

In a digital world, paper and pen have an important but potentially new existence.

Studies have discovered over and over again one remarkable fact; despite the popularity of new technologies, paper and the use of the pen remains a critical feature of work based activities and collaboration.

The challenge for both digital and paper/pen is to interrelate and bridge this apparent divide. This is a challenge that has only recently been recognised.

In this study there is a recognition that paper provides the vehicle, space and medium for collaboration between individuals working as part of a group. The study developed a paper based procedural framework in the form of an assessment booklet. This paper based framework sets out a  structure for collaboration, group interaction and interchange.

The Anoto technology harnesses the successful features of this collaborative paper framework and in addition provides a variety of tools which enhance the assessment of group and individual work. These tools include a facility to a replay the students work as he or she goes through the development process. As the student inputs information in the form of drawings, writing and voice files, photographs and videos, this information is time stamped. This allows each piece of information to be tracked. It also gives a greater insight into the students thought process and evolving ideas. A variety of conclusions can be drawn from this insight i.e. a greater understanding of the interchange of ideas within the group, looking at how one persons idea has influenced another students thinking. Also in other assessment scenarios it may be useful in the diagnosis of conceptual or mis-conceptual understanding. Once the diagnosis has been made the learner can be guided towards an appreciation of other ways of viewing, understanding and or working out that concept.

The third phase of this study will concentrate on how assessments can be made. To develop an understanding of what it is we are assessing in this new interactive and collaborative world. To look at the perceived benefits and efficiency that may be offered by connecting digital and paper based activities.

The study so far has provided a brief glimpse of what may be awaiting. This work is in its infancy but is providing the foundation for a rich and varied source of future research, analysis and development in a newly emerging field.

## References

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