Binary Tools

ABSTRACT

Information technology has permeated virtually all of today's human activities. Digital technology supplies the tools for countless creative practices, however the culture of studio crafts has yet to fully engage itself with these new possibilities. In order for the crafts maker to remain a current and relevant part of contemporary culture it is vital to embrace and utilize these new tools.

This research centres on how digitally based techniques can be realistically utilized within a 'designer-maker' practice. The article is based on practical research and features a series of projects which deal with Rapid Prototyping, CNC cutting, and three-dimensional freehand drawing.

To conclude the article discuses how digitally based techniques combined with traditional craft skills has the potential of forming the concept of the post-industrial artisan.

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INTRODUCTION

Craftsmen have always used tools. Tools are a fundamental concept for creative human activity. The tools might have remained the same for long periods of time but historically artists, artisans, craftsmen and women have used the tool technology that have been available to them at any given time. It is therefore interesting to witness how certain creative practices have almost seamlessly adapted to the current technology by using the computer as their main tool, while others are still to make any real use of the possibilities information technology offers.

It is now almost unthinkable for a graphic designer, architect or industrial designer not to use a computer. In contrast, for the craft oriented trades, such as pottery, glass blowing and jewellery, the use of IT in the creative process is still rare. An obvious explanation is the craft world's own reluctance to embrace new technologies. There is undoubtedly some truth in this, however an opposition to technology in general seems only ever to have been superficial. There are many examples of traditionally minded craft practitioners who happily use the very latest technology, as long as it is not directly related to their work. A survey for the British Craft Council in 1994 [8] revealed that 40% of its members used a computer daily for administrative tasks. In contrast less than 10% of those questioned used digital technology in any of their creative processes.

Lief Vange and Askel Krog

The complicated relationship between the craft culture and technology can be illustrated by a poignant example I experienced during my pottery apprenticeship in the late 1980's. Leif Vange, the potter with whom I was studying, was making a series of giant pots with his colleague, Askel Krog.

By applying traditional craft skills to the limit we managed to create, what was at that time, the largest hand thrown vessels in the world. However, the project became stuck on the issue of firing the pots. Existing kilns would not accommodate such large vessels and the building of a conventional brick kiln would have been unrealistic within limitations of time and budget. The problem was solved by engaging an engineer from the local university, who turned up with what must have been one of the very first laptop computers.

The relationship between the proud potters of Northern Jutland and the purveyor of the emerging knowledge based industries, was almost one of dealing with the devil. Nevertheless by computer simulation the thermal challenges of the high temperature firing were calculated and the engineer designed a kiln constructed by conventional insulating blanket. The kiln was lightweight, cheap and performed exactly as the engineer predicted with the aid of the computer program. With the pots successfully fired, we conceded the result of the project would not have been achieved without the interaction of traditional craft skills and digital technology.

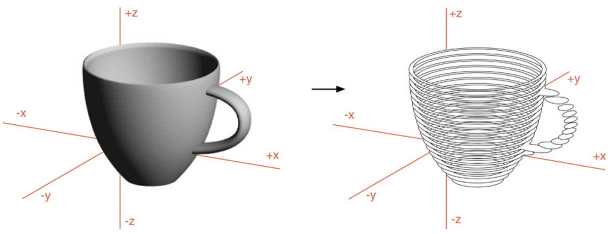
Clearly an opposition to automation and industrialization lies within the roots of the craft culture. This is an obvious factor in crafts uneasy relationship with digital media. However, the opposition to digital media on this basis is ill founded. The new technology offers equal, if not greater opportunity for individualism and far from using computers to automate craft skills the vision for the future should be to develop traditional craft skills in conjunction with the new creative possibilities, or as Malcolm McCullough describes it in his seminal book 'Abstracting Crafts': "Ultimately the computer is a means for combining the skilful hand with the reasoning mind" [4] "Our use of computers ought not to be so much for automating tasks as for abstracting craft" [4]

A more likely reason for the craft sphere's reluctance to engage in IT could lie on a very practical level. The three-dimensional nature of the work has been difficult to apply suitable IT tools to. Clearly three-dimensional Computer Aided Design (CAD) programs have existed for a long time, but compared with two-dimensional programs (such as those for graphic design) they have been very complex and expensive with heavy requirements on the computer hardware specifications. An added issue has been the complication of deriving physical objects from the design programs which until recently required prohibitively expensive equipment such as 'Computer Numerically Controlled' (CNC) milling machines and 'Rapid Prototyping' (RP) technology. However, the availability and cost are easing dramatically so these processes are now a realistic prospect for craft practitioners. The following article will describe practical research into the potential use of these technologies within the context of the craft maker practice.

RAPID PROTOTYPING PROJECT

Rapid Prototyping (RP) is one of the most compelling and tangible of the digital toolset. Rapid Prototyping is a generic term to describe a number of technologies that enables production of real physical objects directly from CAD data.

The principle of RP relies on building an object from a series of stacked cross-sections. A computer model (three-dimensional drawing) is divided into thin layers by the software thereby converting a three-dimensional manufacturing task into a series two-dimensional ones. The object is then constructed layer-upon-layer by a computer-controlled RP machine. The bonded stack of layers forms the final solid object.



The principle of Rapid Prototyping (RP)

The main advantage with the RP technology is that it gives almost total geometrical freedom to create objects that were previously almost impossible to build or required numerous separate development stages.

There are currently five main commercial processes to choose from: Stereolithography, Selective Laser Sintering (SLS), Fused Deposition Modelling (FDM), Z Corp and Laminated Object Manufacture (LOM). The first three provide models in plastics or resins, Z Corp uses a powder (usually plaster) fused with a binder and LOM creates models by layers of glued paper.

RP equipment remains expensive, but the technology is in the process of rapid development with many new processes becoming available. Prices have already fallen dramatically with the increased competition. RP has become well established in several industries where creating realistic presentation prototypes previously would require enormous amounts manual modelling. As RP creates a textured surface (which is characteristic of this process) this technique is rarely used to create the final models to make production moulds from. For this task Computer Numerically Controlled (CNC) machining, which can utilize the same data as the RP process, remains the better option.

First stage - The Contour Vessels

The initial idea for the "Contour Vessels" came from observing the characteristic layered appearance on items created by RP. Normally this visual evidence of the process is undesirable and consequently very thin layers are used to make the smoothest possible surface. However, the layer structure presented aesthetic possibilities, enlarging and emphasising them had the potential of creating a strong visual feature that reflected the nature of the construction process.

Parallel inspiration was drawn from the height indicating contour lines on topographical maps. The method of using contour lines to build a three dimensional model of a landscape is very similar to the way that the LOM rapid prototyping machines builds an object. Thin layers of paper are used to build the shape, the layers are cut with a computer-controlled laser and automatically glued on top of previous layers using heated rollers. After hundreds or even thousands of layers a three-dimensional model is finally created.

To simulate the soft organic look of a landscape initial prototypes were developed by indenting shapes hand-thrown on a potter's wheel. This process then had to be replicated using a CAD program to create the computer files, which are essential for the RP machine to work from. The files were then taken to 'The Advanced Technology Centre', part of 'The Warwick Manufacturing Group' (WMG), were the first two small cup shaped models were produced on using a LOM machine. To emphasise the layers 3mm Medium Density Fibreboard (MDF) was used instead of paper.

MDF model and completed bone china cups

Just like a topographical interpretation of a landscape, the shapes were initially created as completely smooth shapes, only gaining the steps through the LOM process.

Using the RP equipment beyond its normal intended purpose had its difficulties. Constructing from the thicker layers of MDF instead of paper meant that each piece had to be manually placed and removed. This resulted in the otherwise fully automated LOM process becoming very labour intensive. Furthermore each piece had to be cut four times as the lightly powered laser struggled to cut through the MDF, with the machine having to be stopped and reset manually for each run.

The RP technology holds great potential not only for creating accurate prototypes but also for direct manufacture. In this case, however, RP was used only in the initial stages of the model/prototype. The main contribution of the RP process in this project was to add a unique aesthetic that would not have been possible to create in any other way. Further experiments with larger shapes provided very interesting results. By using the same file to build two identical shapes but with one arranged at a right angle during construction resulted in radically different aesthetics with the layers oriented horizontal and vertical respectively.

Bone China Bowl, oriented vertically during the RP process.

To arrive at a finished ceramic vessel conventional model-making skills were still needed. The MDF models had to be developed through a complex series plaster and rubber moulds before working moulds were achieved. From these mould the final pieces were produced in bone china.

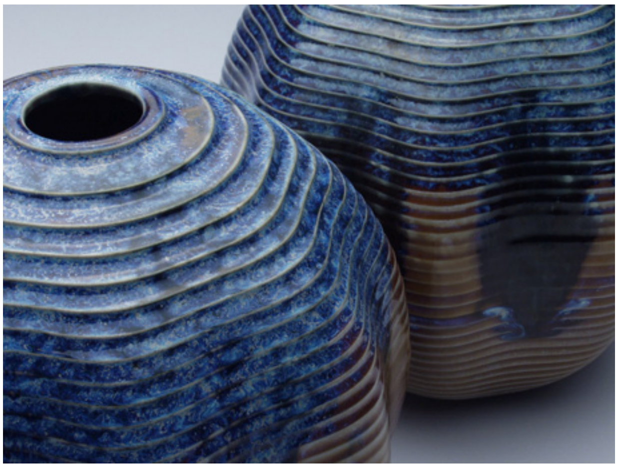
Second stage – The Binary Pottery Project

The 'Binary Pottery' project was the second stage development from the initial 'Rapid Prototyping project', which had explored the layered aesthetic that is so characteristic for the RP process. This project, like the preceding 'Contour Vessels' project was part of collaborative research work in association with The University of Plymouth and Dartington Pottery.

Although the first project had been very successful and resulted in a series of beautiful cups and bowls, there was clearly far greater potential with the concept. The 'cool designed' look of the contour bone china shapes expressed the digital influence very well but that was only one part of the story. There was little visual evidence of the substantial amount of the manual craft skills that were an equally large part of the development process.

It was therefore a core requirement for the Binary Pottery project results to reflect both the high tech origin and the traditional craft skills, which were essential in realizing the final ceramic pieces. For this purpose Dartington Pottery's unique range of reactive glazes would provide the aesthetics that represented the craft skills and influence that had gone into the pieces. These dramatic glazes originate from the legendary Ruskin Pottery [1], had been re-developed by Dartington for a previous project involving 'Spitting Image' creator Roger Law.

For the Binary Project the fluid and volatile 'Theta' glaze was used to provide the base for unpredictable and dramatic surfaces, contrasting against the very 'deliberate' and calculated nature of the shapes.



Jars from the Binary Pottery project

The shapes developed during the first RP project were created on a LOM machine, but despite many attempts with different materials and settings, this process proved to be inefficient. A more productive way of using software emulation to generate the contour lines independent from the RP machine were established. This meant that instead of using the rare and specialised LOM equipment, the shapes could be cut using CNC. As the project progressed it became apparent that CNC machining was becoming ever more accessible and affordable. This meant that we were able to get the layers manufactured by a local metal working company, Luffman Engineering, using their large-scale metal cutting laser. The layer size was increased from 3 mm to 5 mm to emphasise the visual evidence of the layer construction.

The problems of generating plaster moulds from the MDF models still remained an issue. The use of an industrial vacuum former to seal the porous material before the moulding stage helped this process significantly but the project still relied on using traditional mould making techniques to the very limit. With the improved setup of using local CNC equipment and vacuum former, shapes could be developed far quicker and cheaper that with the initial 'Contour Vessel' project.

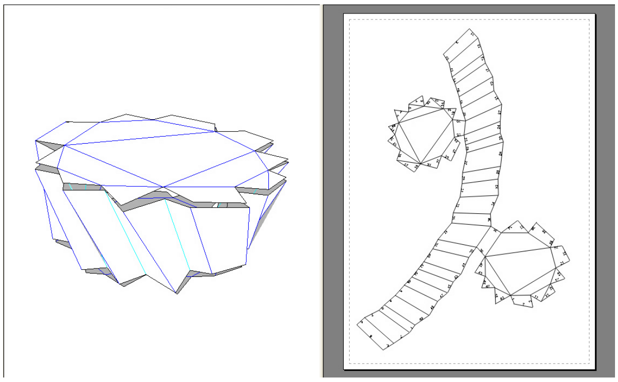
A complete range of dishes and jars shapes were created. The ceramic pieces were made using the conventional technique of slip casting. By using this method the contour lines, which were very defined on the outside of the shape, were also visible on the inside of the piece although appearing slightly less distinct.

Dishes from the 'Binary Pottery' Project

The pieces were finished by pouring with several layers of glaze. This was a deliberate choice and reflected the core intention of the project of representing a visual synergy of digital tools with traditional craft aesthetics.

CERAMIC ORIGAMI

The Ceramic Origami project was based on a entirely different construction method. Instead of the layer building method in the RP process, this project focused on the ability of some CAD programs to 'unfold' three-dimensional objects to two-dimensional patterns. At the root of most computer graphics lies the principle of describing all shapes by flat planes and straight lines. Curved surfaces are simulated by a construction of finely tessellated planes (polygons). This principle makes it (in theory) possible to derive flat patterns from all computer-designed objects. By assembling these patterns it should, be possible to recreate a physical model of the shape (for example in paper). This is still in theory, as the prospect of assembling an object constructed of thousands of tiny triangles with a pair of scissors and a pot of glue is near impossible. However with a pre-determined intention of creating shapes that are suitable for unfolding, this way of creating physical models can be utilised to great effect.



'Unfolding' a shape in a CAD program

The pieces in the Ceramic Origami project were based on designing shapes that had large flat planes which would ease later assembling. The objects were created as extrusions of irregular polygonal profiles, by selecting and rotating the extrusion's end faces, helix-like shapes were developed. These forms were not true helixes, as they contained no curved lines. This was a very deliberate design principle so very simple flat patterns could be derived from these complex shapes. If true helixes had been used, the result would have been highly complex outline patterns impossible to construct into 3D models.

Initially the outlines were printed, cut and glued together, but experimenting with the use of a 'plotter-cutter' discovered a far more efficient solution. This very inexpensive equipment has long been used in the sign writing industry for cutting vinyl lettering. The plotter-cutter is essentially a mini CNC machine with a small rotating knife. By programming different levels of down force pressure for the knife, both cutting and 'scoring' facilities could be achieved. This meant that 'internal' folding edges could be scored before the perimeter of the shapes were fully cut.

After assembly plaster moulds were cast from the patterns. The shapes were consciously designed to require a minimum of the labour intensive plaster mould making processes. The nature of helix-like shapes ensured that each form could be created from a single piece mould, releasing from the mould simply by twisting out like a screw thread. In addition the moulds were made with detachable bases so that the tapered shapes could be cast either way up, enabling two different shapes to be made from the same mould. A large number of different shapes were developed using this method. This process meant that shapes could be developed very quickly and with almost no material cost. The final pieces were slip cast in porcelain and exhibited in September 2004 at the Cider Press Gallery, Dartington, UK.

Slip-casting mould from shape developed during the 'Ceramic Origami' project

The concept of this process holds great possibilities. Although only suitable for certain types of shapes this technique is, both in terms of speed and cost, far superior to RP and CNC. A collaborative project with furniture maker Asaf Tolkovsky, using the same method but with thin plywood as the construction material has shown that the process has potential in furniture making as well as in numerous other applications.

Porcelain 'Ceramic Origami' Vases

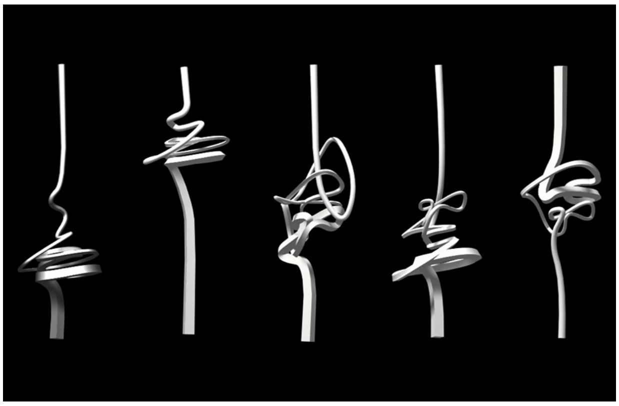
DIGITAL DRAWING

A major issue with the available CAD programs is the alien work situation they present to the average craft practitioner. Creating with a CAD package is essentially a very static and calculating exercise, a process far removed from the traditional craft maker's intuitive making process. This research was intended to investigate how the vast creative possibilities of the digital media could be integrated with instinctive and physical interaction. The project was developed in conjunction with the 'make' research unit, at the University of Plymouth and centred on the used of a G2 Microscribe digitizing arm.

A digitizer is a devise for importing dimensions from physical objects into CAD programs. Digitizing equipment ranges from the very expensive non-contact three-dimensional laser scanners to the basic level 'point and click' equipment. The G2 Microscribe (which falls in the latter category) can perhaps be most usefully described as a conventional computer mouse but with an added Z-axis so the input becomes three-dimensional. Coordinates are entered by pressing a foot pedal or activated automatically by a preset distance of movement (stream line).

G2 Microscribe digitizer

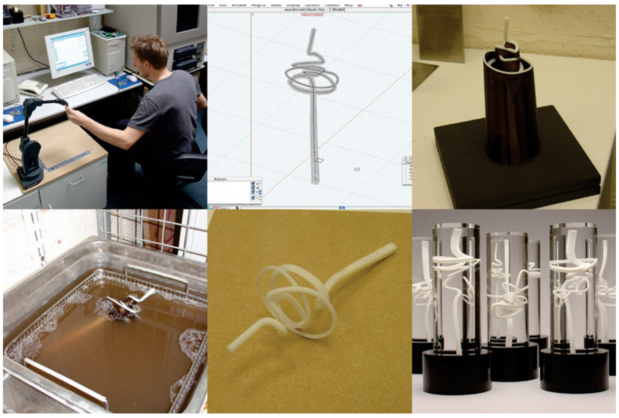
Instead of entering coordinates of existing objects, experiments revealed that the digitizer could be used to record freehand movement in space, and so be used as a highly intuitive three-dimensional drawing tool. During this process data from the Microscribe was feed directly into a CAD program to create three-dimensional linear paths. These lines initially had no volume but though a subsequent process were given thickness by 'sweeping' profiles along their paths thereby creating sculptural forms. From the CAD data physical objects were created using Fused Deposition Modelling (FDM) rapid prototyping.



Three-dimensional freehand drawings done with Microscribe

This process was used to create a series of awards for the 'United Kingdom Science Park Association' (UKSPA), presented in May 2004. The awards comprised of five shapes set in cylinders of clear acrylic resin.

In theory there are no geometric constraints of what is possibly to create with this process: lines can intersect, shapes can be created within other shapes. The main issue with this technique is the limitation of the conventional "Window/Icon /Mouse/Pointer (WIMP) computer interface" [6]. This means that the user has no direct three-dimensional visual feedback but forced to watch the evidence of movement on a two-dimensional computer screen. Research into a combined stereographic (virtual reality) and 'haptic' (touch) interface, is being undertaken by the 'Tacitus' research project [6]. This kind of equipment is however, prohibitively expensive with very high computer hardware requirements. In contrast the G2 Microscribe is affordable and works directly within most common CAD programs.



The process of creating RP models from shapes created by Microscribe drawing

Autonomatic

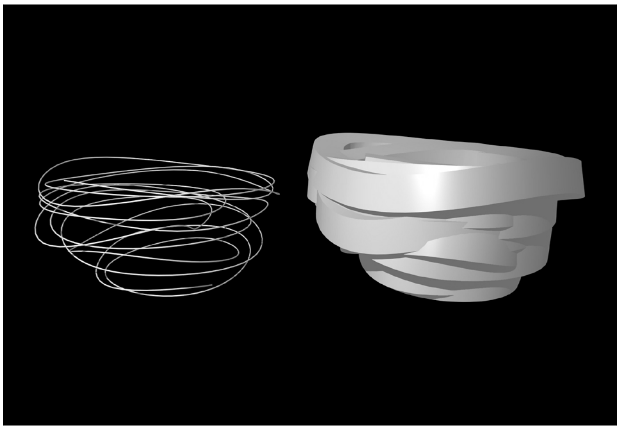
This project, currently under development, was selected as one of two winning projects for the 'Autonomatic' research competition. [3] organized by the '3D Digital Production Research Cluster' based at UCF in January 05. The competition required design research proposals to address the following questions:

"How can digital technologies enable more sustainable designer-maker production? How can digital technologies open up new contexts for production? How can designer-makers humanise objects produced through digital technologies? How can digital technologies provide opportunities for mass customisation?" [3]

Techniques developed during the 'Digital Drawing' forms the basis of this project but instead of the Microscribe, a 'motion capture' device will be used to record shapes described freehand in space. The project offers the possibility of using motion capture equipment, such as the Shapehand™ system from Measureand Inc., which track not only the movement of arm and hand, but also individual fingers. The opportunity of using such equipment offer a much-improved option with the exiting prospect of creating with free and unhindered gestural movement.

While digital media has the potential to free craft practitioners to create beyond the physical constraints of his/her skills, there are still important elements of traditional craft practice which remain relevant and have yet to find a transition into new media. One of these elements is the direct physical interaction of the maker during creation. Creating though a CAD program offers huge possibilities but it is essentially a static and calculating exercise. This process is far removed from the physical and intuitive relationship with form that the traditional craft maker experiences. In addition, there is the important element of 'human evidence', characterized by the minor imperfections that are such a humanising part of the craft object. Digital media offers the captivating prospect of absolute perfection, in contrast this proposal seeks to explore the 'free and informal'.

Initial experiments will explore the development of series of shapes described by linear paths created from captured hand and arm gesture. These paths will be fed directly into a CAD program as basic 'frames' for constructing vessel-based shapes. Vessels are generated in various ways such as 'sweeping', 'lofting' or 'draping'. The expression of the input is left as true as possible, human evidence in the paths, such as 'wobbles and kinks', will not be altered.



Vessel created from free-formed 'path'

The completed files will be realized via CNC milling, using large milling tools to create results which are coarse and direct to reflect the physical nature of the input. From the milled shapes a special technique of one-piece seamless plaster moulds will be used to attain the shapes in ceramics. Creating moulds directly by milling out the negative shape will also be experimented with.

This project, just like the 'Digital Drawing' project, centres on a process that uniquely retains elements of spontaneous human expression in what can be a somewhat sterile CAD environment.

DISCUSSION

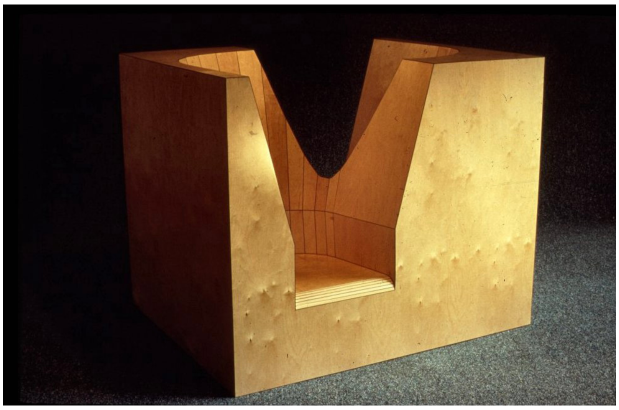
In the last few years the concept of the digitally based maker has made rapid development. It is exciting to see craft/studio makers such as Kenji Toki (Japan), Fred Baier (UK), Olivier Geoffroy (France) and Jeroen Bechtold (Holland) pioneering the use of digital media as an integral part of their practice. These high profile cases hide the fact that the vast majority of craft makers still view IT as something which shapes society around them and not applicable in their own creative work.

There is a great challenge in establishing a public appreciation of a craft maker concept not locked in static traditions but engaging actively with contemporary technology. The growing number of academic conferences on this subject testifies to the increased interest in this area amongst researchers and scholars, but I believe this hides an almost non-existent understanding of the concept within the wider public.

The general conception that to use a computer to create is somehow an 'easy' option, needs to be challenged. Anyone familiar with CAD programs can testify to the large investment of time that is needed to be able to use this 'tool' meaningfully. This is not to say there is no difference between traditional craft skills and the skills employed when creating on a computer. The concept of 'timing' is perhaps the issue that most clearly defines a difference between the two approaches. David Pye's definition of the slippery concept of craftsmanship as "the workmanship of risk" [5] has generally been considered to be the best description of this concept since it was published in his 1968 book: "The Nature and Art of Workmanship" [5]. One could argue that there is no element of 'risk' in creating via a computer program. Unlike the glass blower, who has to apply his making skills within a window of opportunity of a few minutes or the potter who has to create a pot in one specific continuous work sequence before the clay becomes tired and collapses on the wheel. In contrast, designing with a CAD program allows the user to return to any of the previous stages in the creative process to rectify mistakes. This is not to diminish the skill or creativity which is clearly present in the process of creating with IT tools, but to recognise the different nature of the craftsmanship is of an different kind, possibly best described as a 'workmanship of knowledge'.

It is certain that IT will continue to become an ever more integral part of our lives and future generations will regard the computer as an essential element of most creative activities. Clearly IT based tools will continue to develop and become increasingly used. The question is: can we develop the traditional crafts with them? All the projects described in this article depended equally on the use of traditional skills as well as computer tools. Even the most capable CAD designers could not have conceived of the practical application of IT tools in this context. It takes, in my opinion, the intimate knowledge of materials and making processes to utilize the full creative potential of IT tools. IT has a lot to offer the craft maker but the craft maker has also a lot to offer the development of IT.

The use of the computer in a designer/maker practice is not an issue about changing the fundamentals of the concept of the craftsman, instead this should be seen as an opportunity to develop traditional skills with new processes and aesthetics. In a variety of ways the digital media has the potential of freeing the craft practitioner from creating within the physical constraints of his/her skills. New terms for the concept of the digitally based craft maker are already starting to emerge, Malcolm McCullough calls it the "post industrial artisan" [4], Kenji Toki describes it as "hybrid practice" [7].



Furniture by Fred Baier

There are some clear pitfalls as the new creative practices develop. One of the most obvious is over exuberance with the possibilities IT technology offers. It is very easy to be carried away by vast array of new tools presented to the maker and loose sight of what was the initial intention.

The making process has been a significant component in the appreciation of craft products, often as an integral part of the aesthetics in the finished piece. It would be natural for the emerging "digitally based craft maker" to want to communicate the process behind their creation. From personal experience it is doubtful how much interest there is amongst the buying public to learn of creative methods derived from complex IT based techniques. It is possible that the craft practitioner of the future will be required to focus more on the 'idea' rather than the 'process'.

Perhaps the greatest danger presented by the move towards IT based tools is the potential loss of core qualities such as the 'human' and 'personal' elements, which have sustained the "the persistence of craft" [2] and still continues to drive the interest in the subject amongst practitioners as well as the buying public.

Craft has contributed richly to the culture of our society and it would be a great shame to lose the concept of the craft maker. However, the artisan has throughout history used the tools, processes, and aesthetics of the present time. I believe it is crucial, if the craft maker is to remain a current and relevant part of contemporary culture, to embrace and utilize these new tools.

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