This paper leads from a definition of contemporary craft to integration of new technologies in craft practice. Based on practical research into the application of Rapid Prototyping technology together with silversmithing the significants of control over all aspects of these new technologies is presented. The author claims that creative integration of limitations and idiosyncrasies of digital technologies and processes can lead to new work able to extend the boundaries of craft.

Keywords

Contemporary craft, Rapid Prototyping, Fused Deposition Modelling, New Technologies, Craft Practice, Haptic Device.
Introduction

This paper is based on a body of exhibition work, representing the outcome of my practical research on the application of Rapid Prototyping within contemporary silversmithing. Through this research, I have experienced that new technologies paired with craft practice can be a *match made in heaven* - once the craft practitioner is put in control of these technologies. This match places new processes, techniques and materials in the hands of the practitioner and will help shape the value of contemporary craft. Digital technologies are here to stay and have a lot to offer for the craft practitioner. Controlling all aspects of input and output (idea to object) will shift these new technologies to become advanced tools for craft practice. In the context of this paper the technologies considered are Computer Aided Design (CAD) and Fused Deposition Modelling (FDM) a Rapid Prototyping (RP) process. The definition of control extends to all aspects of software and hardware used for the design and production of work. Research into the interface between the maker as user and new technologies is well established. It appears the assumption is that somehow an ideal interface would solve the problem of integrating new technologies into craft practice. I believe this focus on the input side is only half of the solution, instead I like to emphasise the significance of control over the whole digital making process from design to production. How particular qualities of the final output - object - will in turn influence further design of objects based on these same processes and how constrains and idiosyncrasies of technologies can be cultivated creatively.

1. Current Discussion

1.1 Defining contemporary craft

Craft is traditionally linked to manual processes, with the skilful hands of the maker at its centre. The following two statements build on this concept yet leave the door open for further development and encourage more exploration in this field. Margaret Kirkwood a jeweller in Sydney, Australia, says: ‘For me, the crafts are specifically material based, it is about exploration of material and technique and manipulation of technique and through this practice discovering new forms and inevitably developing new technical skills. It is a skilled based practice and requires many years of working to become a master at the craft of making. It encompasses art and design but the essence of the practice is craft and this should be celebrated.’ [1] On the American Museum of Arts and Design’s web-site says of craft: “Craft” as a designation of creative activity, process, method and purpose rather than a designation for a class of objects, reconnects us with our past, but it can also project us into the future. Therein lies its power.’ [2] Both statements anchor the crafts on skill and process yet emphasises the continuum of practice thus connecting the traditional and the contemporary, the past with the future.
Several recent international conferences and on-line fora focus on linkage of new technologies to the future of craft. It seems the question is no longer if or when new technologies will have an effect on craft, but rather what kind of change they might bring. In his keynote address at Craft in the Digital Age [3] at New Hampshire Institute of Art, April 2004, Jay Coogan predicted that: ‘...in a short time, I can well imagine most artists, craftsmen and designers using digital processes with the same comfort level as they use with any of their current equipment and tools to express their creativity’. Stanley Lechtzin, Chair of the Crafts Department at Tyler School of Art in Philadelphia, and a member of the panel of this conference said: ‘It doesn't matter whether you agree with me or not, the technology is here, and it's here to stay’, and that technology provided the freedom, full vision, and full utilization of the artistic intent. Under the title, The Dirty 'C' Word, Karl Chitham writes on the web-site of New Zealand's Artists Alliance: ‘It appears that the current climate is ripe for those wishing to explore work in disciplines previously frowned upon by the establishment, or for those with a vast history and knowledge to expand out from the craft stereotype.’ [4] This positive positioning of craft towards new technologies is supported by research into various aspects of the integration between them.

1.2 Research into integration of new technologies with craft

Any research to integrate new technologies within craft can only benefit through the direct involvement of craft practitioners. Their ‘hands-on’ approach will shape the practical outcomes required to make new technologies a tool for their practice. The following project demonstrated that by giving makers first hand access to these technologies can extend the traditional boundaries of manual making skills and can redefine a craft-based design philosophy.

Phillipa Aitken discussed the TACTICS project, in 1999 at the Computers in Arts and Design Education conference. The TACTICS (Towards Applying Computer Technology In Crafts, Scotland) project, based at the Centre for Research in Art and Design at Gray’s School of Art, Aberdeen was conceived to examine the perceptions held by designer-makers of the potential benefits of exploring new technologies in their craft-based design practice. It was intended that new strategies will be developed and piloted to facilitate the opportunity for makers to engage with these new technologies, in turn perhaps redefining craft-based design practice in the next millennium. [5] This kind of broad ‘philosophical’ research paves the way for more specific investigation. The following TACITUS project (different from the TACTICS project above) is an example of looking at how a craft practitioner could better interact with a CAD system. The lack of dexterity while designing on a CAD system, typically using only a mouse and keyboard, was at the heart of the TACITUS project.
Ann Marie Shillito presented a paper about the TACITUS project at the PixelRaiders 2 conference in April 2004 at the Sheffield Hallam University. A practising applied artist herself, she shared her findings in regards to this project: 'Our research has identified that a niche exists, in the germinal phase of designing, for exploiting the potential of a digital medium with haptic feedback. Such an interface would enable idea formulation and creative activities to be performed with the same intuitive & fluid transmodal interaction as sketching on paper and with as great a sense and degree of engagement as in modelmaking.' The stated aims of this three-year collaborative research project include the exploitation of the advantages of being able to work, think and respond in a virtual environment [to stay] more 'in touch' with creative working practices and to discover the degrees of multi-sensory feedback required for artists and designers to work intuitively using their tacit knowledge and skills. TACITUS was based on the Reachin Technologies using the Phantom Haptic Device that enables users to touch, feel and manipulate virtual environments. The user's dominant hand holds the finely engineered force feedback pen-like mechanism which has had its stylus tip accurately calibrated to the x,y,z co-ordinates of the virtual space.

When I had 'first-hand' experience with such a device at the Haptic Workbench at Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, I was intrigued how convincingly once mind can be fooled by a simulated hand-eye interaction. After distorting virtual material for a while I noticed, that the hardest surface sensation the Phantom device was able to simulate was that of a cricket ball. When the simulated tool silently clicked against the virtual surface, it produced the feel of hitting leather. Being a silversmith I found this feedback irritating and distracting. This kind of research is an example of looking at the 'front-end', the input-side, trying to overcome the limitations of mouse and keyboard while interacting/modelling on CAD system. Over the last four years I was able to use a Rapid Prototyping facility at the Australian National University, Canberra, giving me direct access to the 'back-end', the output side of making based on new technology. I was able to explore the potential this technology holds for my own art practice in and for craft in general.

2 Processes and Outcomes

2.1 About rapid prototyping processes

The following is a brief description of Rapid Prototyping technologies in general and Fused Deposition Modelling (FDM) in particular.

Rapid Prototyping is the name given to a host of related technologies also known as layered manufacturing where a physical object gets directly built from 3D computer drawings (CAD). One can think of this as a printing out of real parts instead of paper documents. All Rapid Prototyping technologies have in common the adding and bonding of materials in layers. In order to build, lets say a cylinder, circular cross-sections are placed on top of each other like a stack of coins. Some use lasers to fuse powder or cure resin while FDM extrudes a plastic filament. There are more than sixty different Rapid Prototyping technologies known most of them under research, some are commercially available and established.
The FDM process by Stratasys \[7\] has a build-head mounted on a mechanical stage able to move in the x and y dimensions to draw the cross-sections on a base. This build-head is equipped with two heated nozzles, one for the build-material and a second one for the support-material. While it is drawing the cross-sections, it extrudes a thin wire of melted ABS plastic. The base is then lowered to make room for the next build layer. The plastic hardens immediately after being deposited from the nozzle and fuses to the layer below. Support structures must be designed and fabricated for any overhanging geometries and are later removed during post processing. FDM seems to be the most practical Rapid Prototyping solution for an educational set-up as it is office friendly and quiet, it can be installed without an air extraction system or a separate break-out room to handle messy materials like resin or fine powder. It only needs mains power and spools of plastic wire.

2.2 About process and control

Michael Rees, a sculptor in Kansas City, Missouri and a long-time user of Rapid Prototyping technologies, writes on his web-site \[8\]: ‘Wysiwyg [What you see is what you get] also means that the facet structure of a model on the computer screen will show up identically in the model.’ This statement is somewhat misleading as it omits the fact that every output device will leave its marks, traces of the process, on the produced part. Inherent to RP technologies is stair-stepping, these real surface features are artefacts created by the build process. These marks will not be visible during the design stage on a CAD program nor ‘touchable’ through a haptic device like the Phantom Haptic Device. To successfully apply these process features one needs to understand the interaction of software and hardware and the build process as well as being in control of every aspect of it. It is this knowledge of the process or its limitations, which could be used in a creative way by the maker.

This process of Computer Aided Design and Computer Aided Manufacturing involves several levels of software and hardware. There is on one side the CAD software, running on hardware which in turn needs its own operating system. On the other side a different software is necessary to prepare the CAD data, the virtual model, to be processed by the next piece of hardware, the Rapid Prototyping machine, which then builds the part. Both have a host of settings and preferences to fine-tune their behaviour and influence the outcome of the built object. One could add to this line-up the controlling software for an input device (hardware) like the Phantom Haptic Device or the software to ‘clean’ the stl-file before it is passed-on to the RP software and finally there are the dials on the RP equipment itself. The usual aim is to achieve a built part as close as possible to the simulated CAD model. As a result the process inherent marks are kept to a minimum by optimising the built set-up. This relates well to the needs of engineers but suppresses creative possibilities with the potential for truly unique work. During my research, I noticed that the most important element to create successful work was my access to the all levels controls of this technology. The access to these controls is typically limited by the separation of the design from the making, a foreign concept to craft practitioners. Once a model has been created using a CAD software, the stl - file is then sent-on to be build by a bureau or in a research lab, which will be managing these expensive production technologies. During the next step the stl - file is prepared by a technician for the build process. That's the moment when crucial decisions could be made by the maker to influence the outcome of resulting object.
2.3 Examples of work

The following two sets of images show how the appearance of an object is effected by changes to the build parameters.

First set shows the same CAD data build in 3 different ways.

*Figure 1* shows the wire frame simulation of the virtual model, the CAD data.

*Figure 2* shows the object built on a Selective Laser Sintering machine. This technology has a high resolution and minimal stair-stepping, the object is a close match to the CAD model.

*Figure 3* shows the same model as in *figure 2*, but build on a FDM system. The image shows the vanishing of facets as remnants of the wireframe and the starting dominance of the FDM build structure.

*Figure 4* shows the same CAD data but scaled down to 20% compared to the objects above. The build structure has cancelled out the underlying CAD wireframe.

*Figure 5* shows an object which had been built on appx. 30 degree angle in relation to the x-y plane.

*Figure 6* shows the same CAD data as in *figure 5*, but the object was built parallel to the x-y plane.

The second set of images show the same CAD data build on the same system with the same parameters but oriented in 2 different ways, which caused a different build pattern for each of the finished objects.

The objects orientation, scale had a direct influence on the decorative qualities of these patterns. Michael Rees comments on this by saying: ‘Stair stepping is another exquisite outcome of the creation of parts in additive fabrication. The surface and its stair stepping comes together on an object in a way that is mysterious and beautiful.’

**Conclusion**

New technologies open up exciting ways for the creative mind to make new work that can exist happily within the context of craft, as long as the hand and the eye is given access to all aspects of control of these technologies. Malcolm McCullough, a Professor of Architecture at Harvard, writes in his book *Abstracting Craft: The Practiced Digital Hand*, that anyone who gives form with software, whether in architecture, painting, animation, modelling, simulating or manufacturing, is practicing personal knowledge and producing visual artifacts that, although not material, are nevertheless products of the hands, eyes and mind. [9]

I like to believe that together with the hands and eyes of the maker works a keen and investigative brain, able to learn from the results of the application of new technologies by closing the feedback loop of design-result-(re)design. Overcoming and controlling the existing limitations and idiosyncrasies of current CAD systems
and CAM will be an important factor for the successful integration of new technologies in craft practice. This match of craft and new technologies will lead to work that can extend the boundaries of what is appreciated as craft.
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Craft and new technologies, implications for practice:  
A match made in heaven  

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