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Crafting the Void: Trans-Dimensionality in Digital and Analogue Craft Practice

This paper explores the place of abstracted practice in craft – made possible by occupying a void left by the Arts & Crafts movement's disenchantment with the machine – by outlining some recent computational practices, notably in digital visualisation, design, fabrication and materials engineering.

The dialogue addresses the interaction of different media and technologies on craft practices in the studio and the factory through case studies that explore both the imitative and adaptive use of digital technologies to instigate and craft ceramic objects, some considered impossible to achieve by other means. An analysis of case studies accompanies a discussion of an emergent research informing a hybrid ceramics practice, signalling a trans-dimensional conceptual framework as the foundation for a digitally augmented future for craft.

The first case study outlines the development of a unique, non-destructive image capture process used to translate complex imagery from an existing porcelain vase to a new form via a two-dimensional image using digital and analogue ceramic studio techniques. The second recounts a 'digital bricolage' methodology used to visualise and generate novel ceramic forms from sonic data via an intersection of 'craft' practices and industrial bone china. Analysis of these and other examples leads to a discussion of the disruption of orthodox craft and manufacturing systems, the reappropriation of technologies during exchange between the studio and the factory, and the convergence of craft and design strategies as a bespoke hybridised practice described by the idea of trans-dimensionality.

The central discourse raises questions of place and meaning in an expanded characterisation of craft's dimensionality, through phenomenological observations of media languages, practices and technologies. The paper concludes with a short discussion of the character of thinking and problem solving associated with digitally mediated craft practice and points to a convergence between craft, design and manufacturing, framed by Malcolm McCullough's (1996) idea of an 'abstracted' craft practice operating in a digitally mediated world.

ReCrafting

What can be made of the renewed recent interest in craft? Whether in art, design, environmental sustainability or the growing 'maker's faire' movement, some of the dirt appears to have washed off. 'Craft work' has recently qualified as award winning conceptual art (Dammann 2005), rekindled experiential perspectives in user-centred design, become a symbol for sustainability through parsimonial reclamation and upcycling of materials, emotional attachment and time, and become abstracted as a metaphor for digital creativity.

This broad coalescence may signal the emergence of a type of 'trans-dimensionality' in craft, and perhaps a redefinition of craft's familiar role in an evolved hierarchy of information/knowledge capital. This paper uses an interpretive examination of craft projects and relevant historical examples to develop the idea of 'trans-dimensionality' and how it comes about.

The 'instrument' takes a central position in this appraisal. Craft can be defined in relationship to its tools, as they physically extend the capacity of the human body, essential to the translation of cognitive and visceral expression into form. Through tools of various kinds, the labours of craft connect work, time, material and beauty.

Tools of God

Craft has historically seen Satan, rather than God, in the machine. Prior to the arrival of industrial machines, the pages of Diderot and D'Alembert's 35-volume, '*Encyclopedia*', (2002 [1751]) were filled with beautifully engraved illustrations of tools used in the making and doing of things. The depictions of craft activities are presented in a visually instructional manner, the 'makers' presented along with tools in hand. The authors describe craftworkers from an enlightened perspective, developing rational arguments for the virtue of their capabilities and achievements creating what McCullough (1996: 12) describes as 'one of the best definitions of craft available'. In the book, countless illustrations help overcome the difficulties of describing the complexities of highly skilled eighteenth-century craft workshops by visually detailing the range of tools and techniques used to produce the finished artefacts (d'Alembert 2009[1751]).

Tools are the physical connection between the hand and material and, by extension, the material interface of process and ideas. Debates concerning both aesthetic and social dimensions of craft and the attributes of craft product quality have persistently addressed the proximity of tool relationships, such as in Volume 1 of *Capital*, where Marx defines the machine as a tool distant from the body, and describes how power is wrested from craft in the factory: 'In handcrafts and manufacture, the workman makes use of the tool, in the factory, the machine makes use of him' (Marx 1996[1887]: 281).

Ruskin also develops a critical social argument around this reversal, situating it as a euphemism for reduced human freedom and non-artistic endeavour (Ruskin 1892[1853]: 20). While Marx acknowledges machinery's threat to craft and other work (Marx 1996: 285), his other observations differentiate between labour-power in manufacture and the instruments of labour in industry, building the idea of a compounding, connected use of apparatus and automation in complex machine systems. In comparing machine and hand tools, Marx's writing points to an emerging 'machine language' in contrast to that of the hand. For both Ruskin and Marx, the machine is equated with perfection and power, but Marx's observations of it are largely developed within an economic and social framework in *Capital*, while Ruskin's rebuttal of mechanised perfection is founded upon a belief that it threatens the 'imperfection' of hand work that he sees as valorising human expression.

For Ruskin (p. 32), the best work, beautiful work, is imperfect for two reasons. Firstly because the primacy of the conceptual will always trump the individual's capacity to physically create it, and secondly for a moral truth drawn from imperfection embodied in the nature of existence, an 'aesthetic' of the natural world that is constantly in a state of flux. Ruskin renders the imperfect object more valuable than the concept it could embody, privileging spirited practice over a more intellectual or abstracted craft that is characterised by work made to a considered or designed plan.

Although visual variations or surface variegation may be acceptable in crafted products, even revered as attributes of the 'hand made', there is rarely a place for such language in Queen's Ware, Wedgwood's Portland Vase or the industrial ceramics legacy it founded. By the time his new Etruria factory was built in the 1770s, Wedgwood had grafted a language of technical and mechanical refinement onto that of his own traditional ceramic craft. The 1789 Portland Vase, Wedgwood's neoclassical imitation of the Barberini glass original was the result of experimentation with new hybrid methods of ceramic production.[1] The vase shape is wheel-thrown by hand, refined by a lathe and the characteristic bas relief cameo scenes applied by hand, using moulded components. Wedgwood's approach leveraged highly skilled operators working with both handcraft and machine processes informed by scientific method, a strategic synchronisation that created new standards in everyday wares and positioned manufactured product as 'art' in the Victorian marketplace. Conceptually, the transitional design and manufacturing model Wedgwood established has changed little since that time.

During the 1950s, Norman Lindsay, a renowned Australian artist, extended his prolific oeuvre to include three vases painted with scenes of Balinese women depicted in a variety of suggestive poses. In 2002, the National Trust of Australia approached Roderick Bamford to assess one of the vases which had badly deteriorated, with a view to its conservation. The paintings, executed on porcelain of German origin apparently purchased from Sydney department stores, were painted in a direct, confident, and highly skilful manner on the difficult glassy surface. A feasibility study for the project[2] revealed that the painting comprised a mixture of pigment types, including low temperature metal enamels and oil-based enamel paints, forming an attractive but technically flawed, impermanent surface. Incompatibilities between painted and glazed surfaces resulted in poor adhesion and peeling, creating conditions which precluded the possibility of successful conservation. Consequently, alternative solutions were discussed, and a decision taken to develop a rendition of the original vase, with developmental research costs offset against the commercial sales of an edition of 300 vases (Bamford 2013a: 2). The research investigations led to the development of a unique process enabling the transfer of imagery from the original vase surface to a newly created vase via a two-dimensional print (see Figure 1). The solution employed Computer Aided Design, 3D printing, photogrammetry, computer mediated pattern generation, slip casting and screen printed water slide decals. Following the success of the first Lindsay vase, the re-creation of a second, named 'Sea Sprites', was commissioned by the National Trust in 2004. Both vases were created as a limited edition of 300, with the aim to faithfully represent both the quality and the spirit of the original piece. In both editions, vases are hand numbered and accompanied by a Certificate of Authenticity authorised by the copyright holders and trustees, H & E Glad.

Figure 1 Norman Lindsay Vase 1 (2003). Completed reproduction. Cone Nine Studios. 250 × 200 × 200 mm. Porcelain and polychrome decals: Photograph: © Roderick Bamford.

Involvement with the Lindsay vase project grew from an interest in using creative strategies to integrate studio and industrial ceramic techniques, in particular the relationship between photographic imagery and ceramic forms. Research led to the consolidation of a novel mapping process for accurately exchanging detailed digital imagery between two- and three-dimensional media, in both virtual and physical form, using the printing process. Although the extent to which trans-dimensional printing may be applied to ceramic form is currently limited by the elasticity of decal required to fit a compound curve, the process was successfully developed for a commercial application in 2004 through a collaboration between Roderick Bamford, the artist Reg Mombassa and the Australian company Manfredi Enterprises. Reg Mombassa's painting was mapped to a decal and applied to a cup designed by Roderick Bamford. The 1000-piece edition of the cup and saucer set 'South Coast Cottages' was manufactured by Monno ceramics in Dhaka, Bangladesh in 2005 and distributed in Australia by Manfredi Enterprises. Examples, exhibited in the 2007 exhibition *Smart Works* at the Powerhouse Museum, were acquired by the institution. This influential survey exhibition showcased the place and meaning of the 'handmade' and 'industry' in design and relationships between individuals and partnerships, nationally and internationally.

The third Lindsay vase project, currently underway in the studio, employs advances on the original method. The separate tasks of measuring a form and photographically extracting its surface imagery can now be integrated using a novel white light scanning process using Photoscan software[3] and an SLR digital camera to capture multiple high resolution images of the vase from overlapping viewpoints. The photographs are post processed in Photoscan, where different settings are manipulated to resolve the camera's lens data allowing the user to arrive at a topologically accurate, three-dimensional computer model with integrated surface imagery (see Figure 2).

Figure 2 Norman Lindsay Vase 3 (2013). Rendered vase image reconstructed from Photoscan data. Photography: © Peter Murphy. Digital render Roderick Bamford. 330 x 180 x 180 mm.

Advances in digital colour reproduction technology for ceramic printing prompted its reinvestigation as a way of overcoming a substantial difficulty experienced in the colour screen printing of the first two vases (Bamford 2013a: 4) and, after successful trials, a digital ceramic printer was commissioned from the German company, INEQS. The digital ceramic printer has enabled a more intimate, in-house understanding and refinement of colour and glaze surface qualities delivering both quality and cost advantages to the project.

It is common in ceramic tableware manufacture for large development and tooling investments in shape to be ameliorated over time using surface decorations to refresh the tableware 'line'. Due to the large volume of printing required for this crude 'mass customisation', screen or lithographic methods of printing are likely to remain the status quo.

Digital ceramic printing is the technology of choice in certain applications, due to the speed, quality and flexibility of image making, affordability of highly customisable printing, and creative opportunities particular to the digital environment. Examples of the latter include the sensitive representation of photographic qualities, fine tonal graduations and colour blends that are characteristically exploited in graphic design software, all of which are challenging to achieve using indirect ceramic print processes.

These trans-dimensional printed ceramic works are cross-disciplinary by nature, incorporating painting, product design, computer modelling, printing and manufacturing. With the exception of cup manufacture and packaging, all other elements of the project evidence coordinated craft processes. Arguably, the majority of skilled ceramic factory processes employed could also be classified as a type of organised craft.

The difficulties of specialisation are highlighted in craft practices that extend beyond the traditional forms of media and are apparent in the minority representation of multi-media craft. Challenges exist not just in the particularities of specific mediums and their integration in finished work, but in the successful integration of craft language. Such complexity is attenuated through the process of design, whereby abstracted instructions, presented through a common methodology (itself another language), organise and articulate the various different stages of product specification and production. But in the process, design often plays the tune for craft, and tool language is highly simplified.

As we have seen, the abstracted planning and control of design have been criticised as a barrier to the rich, tacit expression resulting from fluid cohesive practices of traditional craft.

Machines at war

Whilst imperfection is largely at odds with the aesthetics of manufactured products, simplicity has been a more useful criteria, becoming a mantra of the modern movement that lured artistic intent towards the functional and the conceptual, further separating craft from art and the emerging design. Around the turn of the twentieth century, the ideals of the Arts & Crafts movement were kept alive in Europe and America by two architects with different perspectives on simplification. Frank Lloyd Wright, who designed buildings, furniture and other objects, reinforced the Arts & Crafts movement's integrity of spirit, aligning simplicity with completeness but, unlike the Arts & Crafts followers, he believed the future lay in the machine revealing it (Wright 1901: 87). Here tools were used to reveal the beauty and essence of materials, such as that in the grain of timber.

For Hermann Muthesius, a leading figure in the establishment of the Deutscher Werkbund, precursor to the Bauhaus, machine language characteristically imitated handcraft precedents before finding its own voice. Muthesius saw the greatest authenticity in the forms made possible only by machine technologies, such as the bicycle, but also recognised that an emergence of a new eye to embrace this new purity of a machine aesthetic was necessary (Muthesius 2010: 113). Whilst modernism and its ideology favoured machine aesthetic, this was not an isolated case. The arrival of Dada confronted fascist ideology and the machinery of war. Dada artists legitimised the experimental accident and rejected progressive utility in favour of the contemplation of usefulness.

Benjamin saw the Dadaist collages as 'instruments of ballistics' (Benjamin 1968: 229), denying contemplation by confronting the viewer with an art that destroys their aura and our expectations of their materiality and comprehension. Hannah Hoch's photomontage, *Das Schone Madchen/The Beautiful Girl, 1920,* exemplifies how the new method satirically juxtaposed relationships of gender, industry and power politics within the hybrid cybernetic imagery. It slices viewers' ideas of how things really are. The work of artists such as John Heartfield later developed the technique as powerful forms of graphic design propaganda.

Benjamin's comments ring true in marking Dada as a turning point in the way we might look at craft. In exploding the requirement for holistic perception of artefacts based on a continuity, Dada opened new possibilities for understanding and creating art, design and craft that remain critically important almost a century later, particularly in digital culture. The characteristic cut and paste collages opened a highly effective abstracted route for combining conceptual and visual thinking in the art and design fields, a procedural precursor for the crafting of postmodernism.

Cut, paste and morph enabled the association of ideas, materials and gestures from differing sources in comparative and combinative ways, a structural framework that would later become a metaphor for both the digital interface and architecture in contemporary computational environments.

The accelerating evolution and distribution of computers in the 1980s and 1990s saw the proliferation of inexpensive computer workstations running a range of graphic design, moving image, animation and 3D modelling /CAD software. Desktop publishing and the arrival of the internet accelerated the penetration of digital information technologies and the widespread use of digital languages across a growing array of machines began. Professionals could explore software used in other disciplines as well as their own, and adapt useful features to their own needs, for example in the adoption of graphic visualisation software by architects and the use of 3D modelling programs by animators. The cross-fertilisation of ideas between professionals and the subsequent response of software developers gave rise to a hybridity of both tools and practices.

Collected fragments

The emergence of accessible digital fabrication in the 1990s, such as rapid prototyping, have enabled physical objects to be fabricated from abstract three-dimensional models drawn in computer programs. Following positive encounters with the technology as a communication tool for product design,[4] I began a series of experimental projects exploring the use of rapid prototyping and 3D printing in the crafting of ceramics. Sonic Loop, a slip cast porcelain basket, was initially conceived as a response to the procedural adoption of digital technologies in mass production, where their impact on object 'meaning' remains largely unexamined. However, initial explorations revealed more interesting possibilities to discover how the technologies could facilitate the translation of 'felt' experience into tangible, physical forms. Using digital sensing, prototyping and fabrication technologies, the project explored the idea that a song could be embodied in ceramic form. Sonic information from an oscilloscope was translated into digital data and reconfigured as a three-dimensional wave pattern, swept to shape a sinuous ribbed form. Its dynamics were manipulated to configure the ribbon-like basket with properties that would allow eventual ceramic fabrication using studio tools and methods. To physically realise the form, a rapid prototype of the primary tessellating geometric element was 3D printed, recast to create five plaster copies that were subsequently assembled into the final working prototype. Plaster moulding technologies complete the transformation of gestural and musical intentions into physical form via the slip casting process.

Taking care to avoid warping during the drying stage, foam cradles are used for support, replaced by a slip cast refractory cradle (setter) which supports the object through the firing, shrinking at exactly the same rate to ensure the object holds its form. This support system was adapted from the Bone China manufacturing processes where setters are similarly used to prevent the deformation of pyroplastic clay. This strong visual dynamic of this visually simple, yet complex work defies orthodox ceramic archetypes, appearing as a rhythmic suggestion of harmonic frequency, yet it complies with the requirements of a functioning container able to secure a range of objects from the scale of an egg to a pineapple.

The visible tension in Sonic Loop is expressed through material uncertainty (how could this be porcelain) and additional unexpected qualities, for example, the strange 'un-ceramic' flexibility of the shape and the resonant musical tone it emits when struck. Research for this project was funded through an Australia Council Special Projects Grant, MMM, in 2005, and the works were developed in collaboration with Australian companies Petch Printing and Arptech. Sonic Loop was selected for exhibition at the Australian Pavilion at Expo 2010, Shanghai, and acquired for the permanent Collection of the Today Museum in Beijing later that year (see Figure 3).

Figure 3 Sonic Loop. Roderick Bamford (2007). Porcelain. 380 × 340 × 340 mm. Photograph: © Helene Rosanove.

Sonic Loop explores a hybrid conceptual territory between virtual and tangible form, mapping unseen musical sound onto three-dimensional coordinate space, then making it visible in the ceramic dimension. In doing so, it suggests a model for trans-dimensionality in craft, adopting collage strategies typical of the digital environment. By making the 'heard' tangibly physical, Sonic Loop creates a new sensorial identity, evidencing a hybrid convergence of the natural and technological relationships continually negotiated in contemporary society.

'Collage' has become a paradigmatic computer design methodology, typically expressed since the 1970s as remix culture (Manovich 2007: 7) where 'pure' media works such as music are not only recombined within their own genre but across other common digital computer mediums such as film, typography, graphic design and animation. Despite the origin of 'chance' in remixing, the critic and academic Lev Manovich suggests that a crafting of its hybridity does occur, through 'fundamental techniques, working methods, and ways of representation and expression'.

The extent and cultural importance of 'remix culture' expand beyond the computer and internet to embody much of contemporary cultural practice. Manovich extends the notion of hybridity to a 'deep remixing' of previously separate media techniques and media languages. Although being situated predominantly in sonic, lens and screen based practices, the inherent mutability of underlying binary data suggests that digital media open architecture creates a real possibility for hybridity to cross dimensional boundaries.

Two signatures in particular emerge from the space of hybrid methods. The first is the effect of continuity reflected by Muthesius, where the regular use of affordable, imitative software tools creates a fake representation of the montage, such as can be found in the cheapest junk mail flyer, that exploits bitmapped imagery and fonts habitually harvested from commercial software clip art. The second, more innovative signature is one that is difficult to visually capture, but emerges from a practised knowledge of design software applied in more critical ways. Without the embodied 'nuance' of variation arising from craft processes,[5] the latter is not possible. Both analogue and digital machines can operate in an environment of invariable, precoded possibilities. For analogue machines, this condition is usually commensurate with its design. But for digital machines, with their embedded and connected computers, it is just a logical starting point for variation due to the array of possibilities which can be manually changed by a user through software or mapped using an algorithmic application of known processes.

The first 3D printers, conceived by Chuck Hull and 3D systems in the 1980s,were conceived as industrial tools with the logic of an analogue machine. However it was the experimental, hybrid approach to exploring software and hardware possibilities in the open source community that expanded its accessibility and applications (Bamford 2013b: 61). 'Reprap' 3D printers exemplify the type of remixing that can foster trans-dimensional activities, particularly in craft. Members of large creative online communities[6] openly share the results of experimental activities across the internet in a wide variety of software, hardware and material fields (including traditional crafts practice), spurring a plethora of connective possibilities to create things at low cost. The opportunities are accompanied by a range of ethical questions (p. 63) that are beyond the scope of this paper. Of course, there are knowledge barriers to involvement, but these are somewhat offset by low costs of participation.

3D printers (open source machines in particular) offer a route for digital information to escape its two- and four-dimensional frameworks and, in doing so, connect the three-dimensional sphere. In the context of the networked world, it becomes a model for the trans-dimensional tool. Behind these simple cartesian robotic structures sits a mutable digital environment in which data can be captured, mixed, processed, processed by tools (in different sequences) and output in various ways. It is tempting to think that the 3D printer may be to artefacts what the Gutenberg press was to publishing or the smart phone/tablet to communication.

One way of thinking about dimensionality in craft is to consider what McCullough calls the 'notional density of media' (McCullough 1996: 211). Historically, the physical dimensions of craft are commonly defined by a particular medium and a relatively simple framework of hand tools and processes. This complexity, particularly prevalent in high technology, clouds the difference between the tool and the medium, but he is optimistic that 'under skilled practice, even these tools become transparent, and a sense of medium emerges' (p. 194).

This observation highlights a challenge in computational design and digital fabrication to digest the fundamental intimacies of craft. The haptic sensitivity experienced in the operation of complex machine tools cannot easily match the resistance of media felt by a bare hand or through a simple tool. However, when comprehending the link between material structures and the residual appearance of forces acting on them, we can also gain a visible sense of a medium. A good example of this relationship arises in 3D computer modelling, where the number of points or knots on a nurbs[7] curve can be equated with a particular curvature that is comparably achieved by applying finger pressure at particular points to a sheet of clay. The knowledge required to make this comparison is tacit, gained over countless hours spent with clay and a computer mouse. In the computing environment, the mediation of action by material is more crudely, for example through haptic feedback devices, or indirectly implemented; nevertheless, it can be effective.[8]

But what occurs when the familiar properties of medium change?

The shape of mineral structures in clay determine a range of finished properties, including plasticity, shrinkage, strength, colour and density. Highly absorbent, curled montmorillionitic plates form clays which are too sticky to be easily formed and crack readily upon drying, yet they are useful in small amounts to suspend pigments and in makeup. The upcycled ceramic tableware developed by the GL21 organisation in Japan[9] has been engineered to include 50 per cent of reused tableware from households and dining halls, yet perform well in standard tableware production processes. The recycled clay body fires at a lower temperature and is stronger than a clay made of virgin materials. Recent technical refinements use up to 70 per cent of recycled ceramic in the clay body; however, the subsequent reduction in plasticity will require new manufacturing methods to process it into tableware items. In 2010, inspired by conversations on the issue with a researcher at the Gifu Institute, Yoshikasu Hasegawa, I developed a dispensing head for a reprap 3D printer capable of directly printing a ceramic paste that simulated the newer Japanese recycled body. Despite conceptual success, any ideas I may have had for industry applications were a long way off. Josiah Wedgwood had far more success with experimental scientific methods, systematically testing hundreds of clay mineral and pigment formulations in arriving at the formula for Jasper and Basalt ware. It established a new aesthetic direction in the ceramic medium that spoke of the refined medium and it required new tools, such as the turning lathe, adapted from wood working, to work the clay body. My own experiments did reveal a language of contours that recalled miniature clay coiling, and also a similarity to the layered clay nests extruded by the mud wasp's abdomen. These ideas were developed in a range exploring the language of contours characteristic of the process Fuddling Manoeuvre, a series of 3D printed and cast works for the Australian touring exhibition Hyperclay (2011–14), including the work Fuddling Manoeuvre (see Figure 4), created by purely digital workflows using 3D scanning and direct 3D printing.

Figure 4 Fuddling Manoeuvre. Roderick Bamford (2011). 3D printed clay & glaze waste, 140 × 100 × 100 mm. Photograph: © Ian Hobbs.

Since the IBM logo was written with Xenon atoms, the artificiality of materials has garnered increasing interest as the focus on structure and its manipulation becomes ever smaller. Neither the execution of Feynman's experiment nor a scientific proof of the event could be established without electron microscopy. Such changes to our understanding of materiality bring into focus the relationships between media and medium that form another dimensionality for craft in the abstracted sense. It also announces a privileging of the visual over other human senses.

By categorically dimensioning a medium into its material structures, tools, skills and procedures, a componentry emerges which is akin to the metaphor of 'bits and atoms', the name for MIT's centre for 'creating almost anything'. In Neil Gershenfeld's reductive model (2012), bits are analogous to the tool, the atoms to material. The questions of skill and procedure come later and the notion of 'medium' becomes foggy. Yet, perhaps ironically, the centre for Bits and Atoms has become a type of 'stem' for new craft, spawning 'Fab Labs' across the world where 'makers' explore a multidimensional array of digital and analogue processes, particularly in digital fabrication.

Remix culture is now clearly impacting on the object through an abstracted, formulated materiality. The variety of 3D print media is expanding beyond a fantastic array of properties engineered for style, function and performance, to include organic media for 3D printing of living tissue. Although Gershenfeld claims that digitisation has existed since the age of the ribosome (p. 49), it remains difficult to comprehend that digitally created matter, with its array of distributed form and mutability of content, is anything but a new or newly imagined phenomena.

All craft and design objects (even hybrid ones) reflect conditions in technological society where everyday reality is increasingly interpreted through technological artefacts. The view from an airplane window alters our ground-based interpretation of the environment, the camera and the screen bring to us images unavailable to the naked eye. Other images are digitally manipulated for particular purposes. The latter type of image exemplifies what Manovich calls the 'invisible effects' (Manovich 2007: 1) of deep remixing where authentic representational origins dissolve. Smart phones mediate the ways people, objects and events connect, and online shopping decisions are based on a set of sensory experiences (currently) limited to sight and sound.

For Don Ihde, such conditions describe a reality 'prepared' by instruments in order to be studied by scientists (Ihde 1999: 150). His philosophical argument for an expanded 'hermeneutics' provides a useful framework for contextualising the language of technological objects and their instrumentality that increasingly mediates day-to-day experience. His hermeneutics reaches across the traditional humanities/science boundaries, removing one barrier to a phenomenological discussion of 'instruments' and their impact on human perception potentially reinvigorating a space for the serious study of conditions that could be described as trans-dimensional, or at least the more personal relationships between body, mind, machine and the objects they conspire to create.

Mixed blessings

This paper has introduced some of the ways digital technologies may be blended with analogue processes to develop the idea of trans-dimensionality in craft, but any inference that digital processes are a panacea for craft would be far from true. Whilst the examples represent encouraging explorations into the potential of digital technologies, they do so on the back of challenges that address current tensions between the craft, industrial processes and the desire to solve problems or express particular ideas.

In exposing some limitations and opportunities of both new and old technologies, the concept of trans-dimensionality may contribute something to Adamson's (2007) idea of 'thinking through craft' as a creative, problem-solving tool. Akin to the Deleuzeian interpretation of folding in the Baroque, and the agency in objects described by Latour, the character of trans-dimensionality in craft could be seen as a consequence of deep remixing, suggesting relational quality associated with its constituents, and how they mix or fold in physical and social ways.

The trajectory leaves open the question of whether the character of craft is expanding or being consumed by the extreme abstraction of deep remixing, but the concluding remark is left for the honourable hand in craft, and its persistence. Through the numerous, time-consuming explorations, computer code barriers and transitional complexities aligning digital and physical materials encountered in the examples discussed, the essential procedural steps needed to be articulated by thinking and acting through hand skills. Perhaps this thinking remains a barrier for craft, but it comes with some comfort knowing that Charles Babbage, 'founder of the computer' experienced difficulties in craft fabrication, not theory or maths (Adamson 2010: 48)!

Notes

1. Notes undertaken at the Wedgwood Museum, Barlaston, 1 October 2013.
2. Observations made at the Norman Lindsay gallery, Springwood, NSW during inspection of the vase and studio, documented in the report to the Norman Lindsay Gallery, November 2002.
3. Photoscan Software, published by Agisoft LLC, 27 Gzhatskaya Street, St. Petersburg, Russia 195220 (http://www.agisoft.ru/products/photoscan).
4. During the late 1990s, rapid prototypes of tableware designs were used to successfully resolve problems arising from offshore manufacturers misinterpreting specification drawings.
5. Nurbs: Non Uniform Rational B-Splines, a type of parametric curve commonly used in CAD and 3D modelling .
6. In craft practice, greater variations in material availability, refinement and range of techniques contribute to physical and visual diversity in completed work, regardless of differences in skill levels of the individual craftsperson, the machine operator or designer using computer software.
7. For example, http://www.3ders.org and http://www.thingiverse.com
8. For a rather humorous example, see the smart phone app 'Let's create pottery', created by Idreams (http://www.idreams.pl/en/our-products/show/product/21-Lets-Create-Pottery).
9. GL21:GreenLife 21 is affiliated with the Gifu Prefectural Ceramics Research Institute, Tajimi, Japan.

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