Next Stages in Automated Craft

The Integration of Rapid Manufacture Technologies into Craft and DIY Applications

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Abstract

Advances in the sophistication and affordability of rapid manufacture technology has started to pave the way for home use (Malone and Lipson, 2007a; Burns and Howison, 2001). This paper explores scenarios linking the potential of such technologies to craft and DIY use. While certain forms of automation and semi-industrial processes are already familiar in this area (knitting and embroidery machines, laser cutting), it is suggested that the next stage of development will involve more complex processes, currently more closely linked to applications of rapid prototyping. The improvement in entry-level CAD software (both 2D and 3D) has brought an increasing number of unlikely end-users into closer contact with the kind of processes normally associated with mass-manufacture or the professional practice of industrial design (Gershenfeld, 2005). Such users are not merely replicating industrial processes however, but are modifying and experimenting with both the machines and materials available to them. Future processes might be accessed remotely, some of them through browser interfaces, or eventually housed at home as is the case with home knitting or printing solutions. The paper presents examples from a project undertaken by postgraduate industrial design students investigating the possibilities of future manufacturing scenarios. It also demonstrates the broader potential of exploring this issue in the area of design education. Illustrative examples are taken from a project undertaken by postgraduate industrial design students and also demonstrates the potential of exploring this issue in the area of design education.

Introduction

Promotional material for the UK Crafts Council premier selling exhibition, ‘Origin,’ expands on their tagline “Made Not Manufactured,” with the statement “Making not manufacturing is the single most distinguishing difference between a maker and designer” (Crafts Council, 2010a). This places the current debate right alongside the historical anxiety about notions of craftsmanship at the dawn of the Industrial Revolution. Less than 10 years previously the same institution had proudly celebrated the established ‘design-and-make’ culture in their ‘Industry of One’ exhibition (Crafts Council, 2001a). This apparent distancing from manufacturing technologies would seem to be at odds with the prevalence of high-tech production methods in all areas of craft. This paper looks at some of the influences and practices behind these apparently contradictory positions with a particular focus on craft practices which are embracing automated manufacture at some level, be this high-tech or low-tech. As a means of helping visualise how technologies might develop further in this area, a group of Postgraduate design students were briefed to come up with a range of alternative scenarios. This not only gives an impression of the vast range of approaches that are becoming possible, but also the potential of this subject in the teaching of industrial design – a discipline that has, since its pioneering days, straddled the boundary between craft and automated production.

What is Craft?

Defining ‘Craft’ is no easy task, a fact demonstrated by the Crafts Council’s listing of not one but six different interpretations (Crafts Council, 2010b). Greenhalgh (2003) warns that “craft has changed its meaning fundamentally at least three times in the last two centuries, and it means fundamentally different things from nation to nation even in the Western world.” Given the difficulty of arriving at an agreed upon definition, it is perhaps more fruitful to examine some of the underlying characteristics of ‘Craft’. In order to understand these characteristics, and to determine whether their differences to those of ‘Design’ remain relevant to today’s practitioners, it is necessary to look at the historical basis of the divide between the two disciplines.

Pre-industrialisation, craft was simply the way in which goods were manufactured. Throughout Europe the Guilds operated a ‘closed shop’ system wherein master craftsmen would pass on knowledge to their journeymen and apprentices, carefully guarding trade secrets and protecting their members’ interests (The Guild of Master Craftsmen, 2009). The first wave of industrialisation, which saw a decline in the power of the guilds, involved attempts to incorporate machines to make what had previously been crafted; thus craft and industry became two approaches to the same end. Josiah Wedgwood, one of the best known of the early industrialists and himself a master craftsman, pioneered the use of moulds rather than potters’ wheels and transfer printing rather than hand-painting, as well as being involved in the development of bone china (Raizman, 2003a; Dolan, 2004). The purpose of such innovations however, was to equal the best that craft could produce, such as the Chinese porcelain which Britain’s expanding middle class increasingly demanded as a sign of its good taste.

It was not until the second stage of industrialisation – the standardisation coupled with increased automation characterised by the ‘American System’ of manufacture – that the relationship between craft-made and industrially produced goods was to completely change. This was the point at which the quality of machine-made goods not only equalled, but began to surpass, that of craft-made products. As previous commentators have noted, this was the point at which design began to be seen as a distinct discipline:

> “It was the gradual introduction of more intensive labour divisions, power-driven machinery, assembly lines, and growing automation which brought about the separation of craft and design and which prompted the well-known debates about the fate of art and craft in the age of mechanical production and reproduction” (Walker, 1989).

The well-known debates to which Walker refers were first begun by John Ruskin. Ruskin’s views on craft products versus industrial products were informed by his social theories, on “an elevated view of labor, which he felt was fundamentally undermined by mechanization, the division of labor, and a capitalist system that increasingly alienated workers from the products of their efforts” (Raizman, 2003b). For Ruskin, the division of labour was a major cause of unhappiness amongst the working class, who were forced to undertake monotonous work without ever seeing the end product of their efforts. “In other words, Ruskin advocated no particular style or set of rules for designers to follow other than that the work be a unique creation reflecting the skill, pride and effort of the craftsman” (Raizman, ibid).

This concept of craft – the unique product of the maker’s unadulterated skill, rather than the designer’s multiply-replicated, commercially made products – was one which prevailed through much of the history of ‘Craft’. Gradually craft came to be viewed not as a pre-industrial method of manufacture, but as a process of experimentation with form, material, technique, etc, the result of which was likely to be appreciated more for its aesthetic than for its function. As such, craft aligned itself more closely to art than to design, to the extent that James Noel White, speaking about the 1973 exhibition ‘The Craftsman’s Art,’ claimed that “painting is becoming sculpture, is becoming ceramic, is becoming three-dimensional weaving, is becoming jewellery” (quoted in Sparke, 1987).

It is worth noting at this point that the concept of craft outlined above relates only to contemporary craft, sometimes referred to as ‘studio craft’. There is, however, another notion of craft: that practiced by amateurs and hobbyists, taught in evening classes and sold at fairs, and almost exclusively disregarded by contemporary craft practitioners, as well as designers. If contemporary craft involves investigation, this amateur craft is its direct opposite – an avoidance of experimentation in the desire to uphold tradition. As Hughes (2004) notes,

> “the studio crafts were born out of modernity and created by the same forces that produced the industrial revolution. They are utterly unlike the traditional crafts, upon which they have so often drawn, in that they are practiced in the context of an information age that provides both imagery and technical knowledge to which traditional crafts people would not have had access.”

Yet despite these differences, amateur craft involves an attitude, a do-it-yourself mentality, which values learning, self-reliance and the rejection of (some elements of) consumer culture. These attitudes are also beginning to make themselves felt in the growing phenomenon of automated craft. If contemporary craft had come to align itself more closely with art, in recent years a shift has occurred which has seen craft and design move closer together. Whilst in the past, in truth, there have always been links between the two (most notably in the Nordic countries), this has tended to manifest itself as craftspeople engaging with manufacturers to design mass market products (Fiell and Fiell, 2002). More recently, as exemplified by groups such as Droog, Front and the Campana Brothers, designers have adopted the approaches and techniques of the crafts to design unique or low volume products (Lees-Maffei and Sandino, 2004). This blurring of the boundaries between craft and design has not been met with uncritical approval by the crafts movement, Risatti (2006) for example, claims that

> "The craftsman always ends with a finished original, a one-of-a-kind object. Such individuality occurs even when the craftsman makes several objects of the same type, as in a dinner service or a set of chairs; each object simply enlarges the set to which it belongs. This, however, is not the goal of the designer."

Others have concluded, however, that such distinctions no longer have relevance. Simon Blattner, commenting on the California College of Arts and Crafts (CCAC) change of name to the California College of Arts (CCA), proclaimed that "in today's world… the artificial boundaries between art, design and craft that were so important to the 19^{th} century academies no longer exist" (Blattner, 2003). Corinne Julius (2010), whilst warning against design's cheapening of crafts' ideals, nonetheless admits the difficulty of distinguishing between designer and craftsperson. Yet despite this overlapping of craft and design, one key difference has until now persisted - the need for the involvement of the craftsperson in the manufacture of the object, rather than the design of the object for production by machine – what Greenhalgh (2002) describes as "the direct intervention of the maker in the material process."

What is Automated Craft?

One of the first people to raise awareness of 'automated craft' was Malcolm McCullough, who in his 1996 book *Abstracting Craft* asked "What are the implications for art and craft as atoms become replaced by digital signals and the physicality of reproduction becomes a 'virtual' on screen experience?" (McCullough, 1996). In the years that followed a number of crafts practitioners began to explore McCullough's question, such that only eight years later Bottomley and Goodwin (2004) felt able to claim that the

> "technological/craft debate is history. The technology is readily available and being used by an ever-growing numbers of designers and especially the new emerging makers. Pandora's Laptop has been opened and that particular digital genie is out of the bag."

Speaking at the 'Craft in the Digital Age' Conference at the New Hampshire Institute of Art, Coogan (2004) 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." Lechtzin (2004) was even more emphatic, arguing "It doesn't matter whether you agree with me or not, the technology is here, and it's here to stay."

Such certainty is not universally expressed throughout the crafts world. McAuley and Fillis (2005) define a craft object as one “which must have a high degree of hand-made input,” although “not necessarily having been produced or designed using traditional materials.” Risatti (op cit) goes further, denying the status of craft to any digitally manufactured object since “the effort and skill necessary to bring objects into being simply loses its meaning because it is cut loose from this encounter between a maker's hand and material reality.” Those utilising digital technologies reject such arguments however, contending that the notion of ‘hand-made’ is only one characteristic of craft, and that “these are not the values that should continue to define ‘craft’ in the 21st century and that the one-off, hand-crafted ideal of the craft practitioner is being, and should be, vigorously challenged” (Livingstone, 2002). Technologies such as 3D CAD modelling and CNC machining have presented the craftsperson with new opportunities to explore form, material and process, opportunities not possible outside of a digital environment (Hooper, 2004). It is the increasing availability of rapid manufacturing (RM) technologies however, in particular additive manufacturing, which truly open up the possibilities of automated craft.

Whilst a CAD model may describe a complex form to a degree of accuracy which would otherwise be impossible, a CNC lathe or milling machine is bound by the same constraints as its human-controlled predecessors. The use of technologies such as 3D CAD and CNC machining, as described in the work of Hooper, therefore represent a limited view of the opportunities afforded by automated craft. A hollow shape, for example, in which the opening to the negative volume is smaller than the CNC cutting tool, would be impossible to make in one piece. Additive manufacturing technologies such as stereo lithography (SLA), stereo laser sintering (SLS) and fused deposition modelling (FDM) work in an entirely different way, constructing a solid part layer by layer (Hopkinson and Dickens, 2001). This allows for the design and production of objects which could not be manufactured using conventional processes. The potentials offered by these processes are central to the work of a new genre of craftsperson, such as the three practitioners below, working in the fields of ceramics, jewellery, furniture and tableware.

Michael Eden

Michael Eden originally trained as a ‘traditional’ ceramicist, hand-throwing clay pots and using them as the basis for his exploration of the material qualities of clay, slip and glaze. However Eden’s interests changed during his MPhil. studies at London’s Royal College of Art, and he began to investigate the potential of software to control and limit the parameters of a design. This in turn has led to his use of additive manufacturing technologies to create limited edition ceramic pieces. Eden’s *Wedgwoodn’t Tureen* is rapid manufactured in a gypsum plaster and impregnated with a proprietary material from French RM specialists Axiatec to make it harder and more durable. The piece is based on a tureen from the 1817 Wedgwood catalogue, which Eden recreated in Rhino (a 3D CAD modeller). He then used an image map of bone (the original tureen was made in bone china) to ‘pierce’ the model and cut holes in it. A similar computer modelling technique was used in *À Rebours*, this time using icons of contemporary popular culture to pierce the holes in the vessel. The tureen was rapid manufactured in SLS nylon, then coated in a non-fired ceramic with gold leaf applied in specific areas.

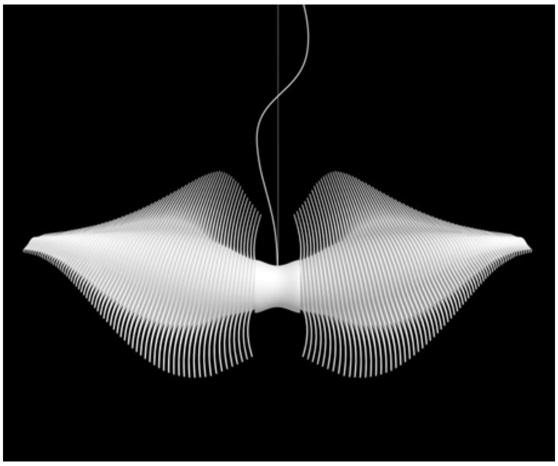
Wedgwoodn't Tureen

À Rebours

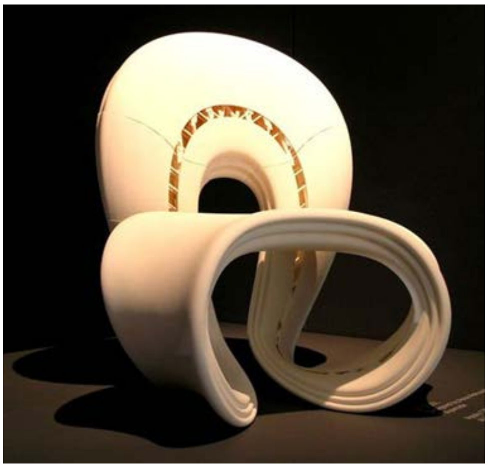
Assa Ashuach

Assa Ashuach is a designer, much of whose work stems from a close collaboration with EOS, a manufacturer of RM laser sintering systems. Ashuach's *AI Light* consists of two 'wings,' each made up of a number of radiating fins, and is produced in SLS nylon. Inside each wing are two actuators, one to control bending and one to control twisting; these allow the light to perform fluid, organic transformations, rather than harsh, robotic movements. The light has five senses that track changes in its environment and slowly it develops a set of behaviours that indicate a new character to each light.

Finite Element Analysis (FEA) is a technique which is usually used towards the end of a product's design, to understand where a part might fail due to weaknesses in material. In the *Osteon* chair, Ashuach used a process he describes as FEA in reverse: first a set of ideal criteria were formulated, material structures were then calculated to meet these criteria using modified FEA software, and finally the chair was designed around the calculated structures.



AI Light



Osteon Chair

Lionel Theodore Dean

Lionel Theodore Dean is the driving force behind Future Factories, and was one of the first designers to understand and begin to explore the ability of rapid manufacturing to produce individual, unique products. As with Ashuach, the computational processes he has developed are an inherent part of the resultant products. With *Holy Ghost*, based on Philippe Starck's Louis Ghost chair, a computer script places a number of 'buttons' within a three dimensional 'envelope' which determines the shape of the back. In the second step the script 'expands' the buttons in a uniform manner until they touch. Finally the individual buttons expand in a non-uniform manner to take up the available space, this is what results in differently sized buttons. A series of springs link each button allowing the whole of the back, constructed from SLS nylon to flex. The *Icon* pendant, produced in a limited edition of one hundred unique pieces, is made in SLS titanium, which is then polished using an automated process. Since titanium cannot be soldered, the pendants would be virtually impossible to produce by conventional manufacturing methods: Dean also believes that the *Icon* series demonstrates the possibility of individualised designs which nonetheless retain an identifiable 'meta design'(Atkinson, 2008).

Icon Pendants

Holy Ghost Chair

Neither Eden, Ashuach or Dean would qualify as craftspeople under the criteria stipuated by McAuley and Fillis, and Risatti, earlier in this section. Yet it is difficult to argue that their explorations of materials, their development of new processes and their pushing of the limitations of additive manufacturing are not closely aligned to the ideals of contemporary craft; an argument supported by the purchase of Eden’s work by the UK Crafts Council for its permanent collection. This is only one strand of contemporary craft however, a second strand, perhaps even more subversive to the traditional definition of craft, involves amateurs and hobbyists experimenting with RM technologies.

Additive Manufacturing Technologies in the Craft and DIY Fields

2005 saw the release of a book which brought the awareness of ‘fabbing’ – manufacture by consumers, of their own designs, often in their own homes – to a whole new audience. In ‘FAB: The Coming Revolution on Your Desktop’, Neil Gershenfeld (op cit) showed how the growing availability of RM devices, together with cheaper CAD software, was allowing users to design products to meet their own unique needs. Nowadays anyone with an internet connection has access to a variety of RM processes, and inevitably the use of these technologies by amateur craftspeople is increasing.

The Hardware Problem

Gershenfeld (ibid) suggests that there are three routes by which any new technology (or use of technology) can move from a position of being of interest only to specialists, to a position where it is considered mainstream by the mass market. In the first, the new technologies gradually filter down as they become better understood, as costs become cheaper and as increased consumer awareness pushes up demand. This is the most common model of consumer adoption, and can be seen in technologies as diverse as CD players, anti-lock braking systems and 'plastic' surgery. In the second scenario, a technology is developed to meet a demand that has not previously been recognised; Gershenfeld uses the example of ink-jet printers, which gave home users access to high quality type and images for the first time. Finally a new technology can be 'appropriated' by consumers and used in ways which the established industries cannot conceive; the rise of 'home computers', which led directly to the growth of companies such as Apple and Microsoft, is often used as a leading example Malone and Lipson, 2007b). These three routes, and the ways they are being used to progress the notion of craft by amateur practitioners, are explored further below.

As an example of the way in which a new technology filters down to the mass market, Gershenfeld uses the case of the laser printer. The assumption governing the design of early laser printers was that the market was interested primarily in accuracy and throughput: in 1977 the Xerox 9700 was capable of printing 120 pages per minute. This assumption continued throughout the product's evolutionary development which, although it happened quickly (Hewlett Packard launched the first LaserJet model, which they dubbed the world's first desktop printer, in 1984), the industry was dominated by established manufacturers developing the technology in their own labs. Gradually these printers found their way into smaller offices, graphic design firms, and high-street print bureaus, meaning that almost anyone with a home PC could afford to produce professional looking documents. Colour laser printing was perfected, and demand inevitably led to cost reductions, such that today it is possible to buy a black and white laser printer for less than $100.

A similar progression can be seen in the adoption of rapid manufacturing technologies. Initially such machines were affordable only to the in-house R&D departments of large corporations, but as prices decreased, dedicated bureaus began to appear. Whilst not necessarily as visible as high-street stores, the ability of customers to transmit files via the internet again meant that almost anyone with a PC, and the ability to create a 3D CAD model, could manufacture a physical object. Another manifestation of the print bureau are online services such as Ponoko, Shapeways and iMaterialise, whose interface and pricing are geared specifically to the non-professional designer or craftsperson. Furthermore Ponoko and Shapeways also provide an online store, whereby designers are able to sell their products to others.

Gershenfeld's second method of technology adoption is more difficult to compare directly to RM. The nature of the scenario is that the technology is entirely new, which implies there are few early signs of its appearance. An example of a new approach is that of Mcor, whose machines use paper as the build material, however the strength of the resultant models is such that it is unlikely to prove a real alternative to more conventional methods.

The final method of technology adoption is that of ‘expert amateurs’ taking an existing technology and reconsidering the way it should be used. In 1977 Ken Olsen, founder and CEO of Digital Equipment Corporation (DEC), said in a speech to the World Future Society that he saw “no reason for any individual to have a computer in their home.” Olsen has since insisted that his prediction should be seen in the context of what was widely understood at the time by the term ‘computer’ – the mainframe and ‘mini’ computers with proprietary operating systems of the type which DEC were manufacturing – nonetheless, the year before Olsen made his statement, Apple had released its first computer, the Apple-1, consisting of no more than a circuit board, some parts and an instruction manual on how it should be assembled and programmed. The user needed to add a case, a keyboard and a display. Yet what the Apple-1 allowed, together with other early personal computers such as the Altair 8800 and the IMSAI 8080, was the opportunity for electronics hobbyists to program machines for the first time.

These early computers are interesting because of the parallels with additive manufacturing systems today (Malone and Lipson, ibid). The business models of established industry players such as 3D Systems, Objet and Z-Corp are to manufacture the equivalent of mainframe computers and sell them to large corporations for often for hundreds of thousands of dollars. Until recently the home enthusiast was unable to gain access to a ‘3D printer’ and experiment to find out its capabilities. This changed with the launch of the Fab@Home machine in 2006, sold as a kit of parts (although pre-assembled models are also available) with instructions as to how to put one together. Users are encouraged to experiment and modify their machines, and then share their expertise in the spirit of open source development. This culture of experimentation has produced results outside of the possible commercial realities of the industry, with users modifying their machines to print in rubber, chocolate and even cream cheese. Other similar initiatives include Makerbot Industries (similar to Fab@Home, though smaller), and CandyFab, a machine which uses molten sugar as its build material.

The Software Problem

Rapid manufacturing relies on the ability to build a digital model in 2D or 3D CAD. Whichever method of adoption occurs for the introduction of RM technologies, however, one stumbling block for those interested in designing and manufacturing their own products is the complexity of software.

Typically CAD software requires a substantial investment in time in order to gain even a basic expertise. In the authors’ experience it can take three years of on-the-job training and experience before the user ‘masters’ the software. Writing about this in ‘Fab,’ Gershenfeld (op cit) notes that “there’s been no compelling reason to make engineering software easy to use; these programs have been written by engineers, for engineers, who make a career out of using one of them.” Clearly there is a reason for such complexity: designing and engineering a high technology product is a complex task, and the design of a passenger aircraft was no easier for the average person to understand before CAD software was invented. Nonetheless it is true that for non-experts, simply looking at the user interface of a typical CAD software package is intimidating, with its seemingly endless icons and drop down menus. Crafts practitioners such as Eden and Hooper have proved willing to dedicate the time needed to learn such a system, but this is unlikely to be the case for those practicing craft as a hobby, thus software with significantly reduced complexity is required.

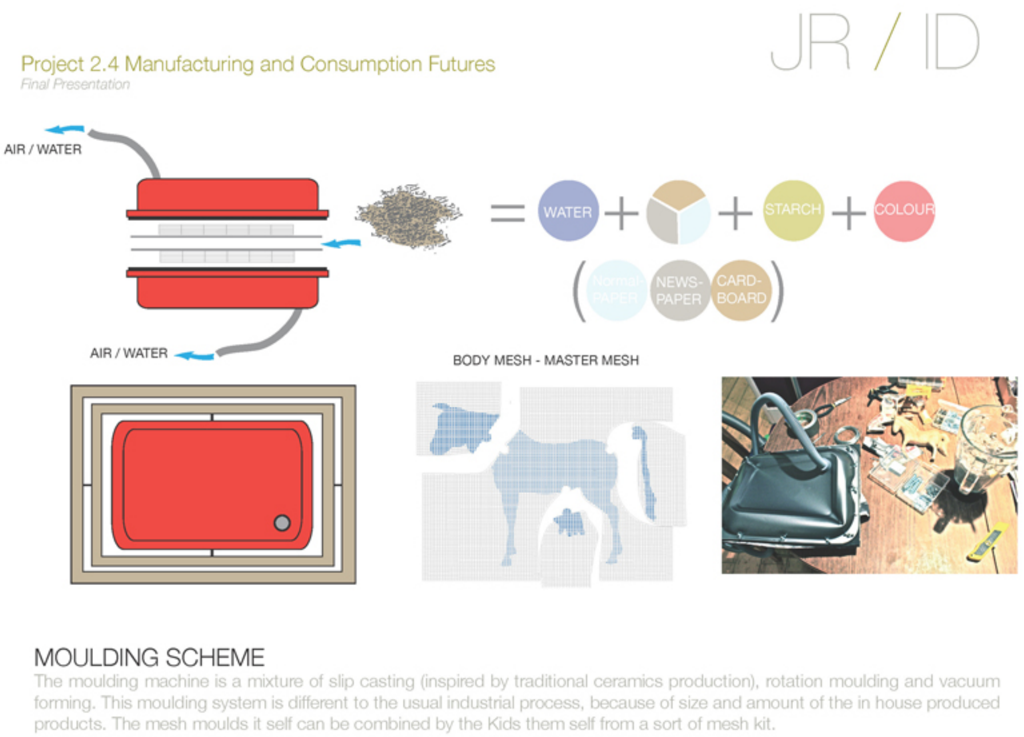
Examples of ‘easy-to-use’ CAD software are beginning to appear, though they are not always easy to find. One of the best known examples is SketchUp from Google, which is available to download for free. Initially envisaged as an architectural modelling package, it has increasingly been used to model furniture and products. SketchUp uses a combination of solids and surfaces, which it calls faces; faces can only ever be planar, which means that not only is SketchUp functionally easier to master than a typical CAD package, it is also conceptually easier to grasp. Clearly the types of products which can be modelled in SketchUp cannot have the sophistication of surfacing as products modelled in more complex software. Their advantage is that they enable users, with no professional training, to create 3D models; in that sense an unsophisticated modeller is preferable to no modeller at all.

Another free-to-downlaod package is Sculptris; a modelling package which differs from typical design or engineering CAD software and allows the user to ‘sculpt’ – to form or cut away – material in a 3D digital model. Similar software is often used in the film and games industries and is not, in itself, particularly ‘simple’ to use. However its way of working and the digital tools involved may be easier for craftspeople to master as they are conceptually closer to the act of forming craft objects in real life.

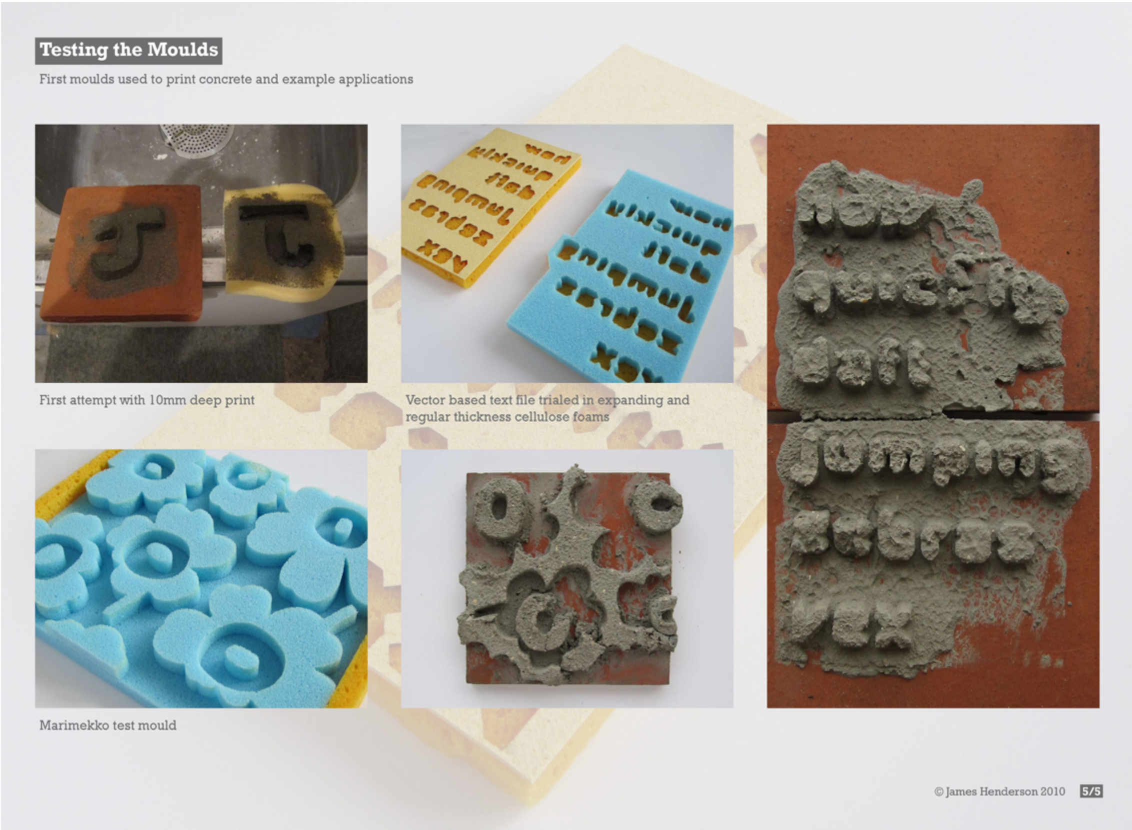
One final approach to the modelling of products bears very little relation to CAD. In the computer game *Spore*, players create a character by first deciding the traits of their creature (strength, speed, carnivorous tendencies etc), and then building the creature from a kit of parts. The ‘modelling’ software for the character has built-in intelligence, such that if a creature has two legs, for example, the software understands those legs should go on either side of the body, rather than both on the same side; Similarly it understands that hands should appear on the end of arms and that eyes are placed on the head etc. Clearly it is not an enormous jump to imagine this idea of ‘guided design’ being applied to products, such that consumers are prevented from making bad decisions. Quite whether this can be deemed craft is perhaps another question, but obviously the notion of automated craft involves the consideration of the software needed to model an object just as much as the machines required to manufacture the object.

Introducing Automated Craft to Industrial Design Students

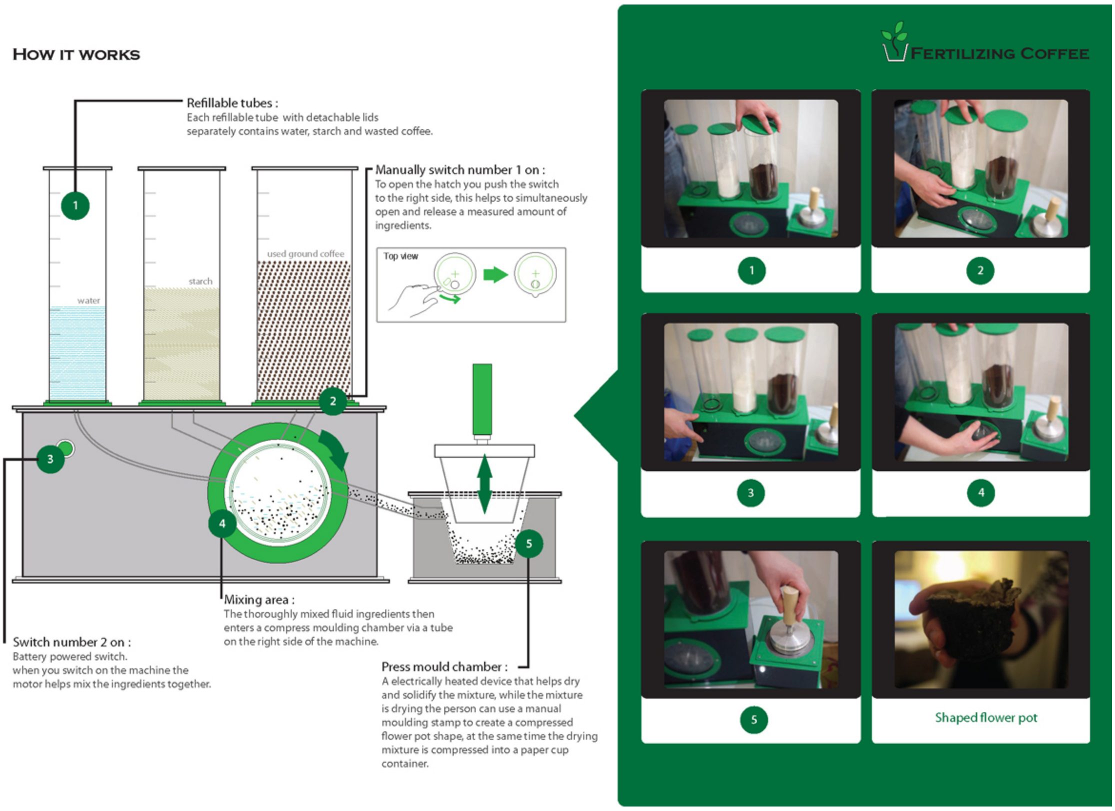
The discipline of Industrial Design is a dynamic entity. Effective practitioners need to keep abreast of developments in materials and processing technology as well as cultural and market trends. At masters level, the focus of research extends to the forecasting and envisioning of future scenarios in various forms. This gives students the opportunity to experiment with material not simply linked to immediate trends and the risk-averse conventional marketing intelligence. The primary source for such future forecasting tends to be from industry and government think-tanks and white papers, providing a rich source of scenarios that designers can then populate with material culture. Such scenarios rarely focus on the means of production, though, and apart from reference to nanotechnology in the vaguest sense, there is clearly no understanding about how such technologies will evolve into products or services. The image of how rapid manufacturing technologies will evolve is dominated by a somewhat technical focus, with little detail on how these things will play out in the real world. This is an area where industrial designers can excel, and has proven to be a fruitful subject for first year masters students. A group of 27 students were introduced to the area of rapid manufacture through visits to rapid prototyping facilities, design studios and the headquarters of Unto This Last in East London, as well as lectures by specialists in the area such as David Tonge (The Division), Michael Eden and Chris Longmore (Drive Design). These different approaches were linked in the brief which asked students to develop and prototype a rapid manufacture system based on an automated technology of some sort. Being a relatively short project (6 weeks), these were not in the main working prototypes, but each student managed to produce realistic scenarios in which a technical process was married with a new application and context of use. The brief did not specify any process in particular and apart from the department rep-rap machine, all processes needed to be sourced or created by the student. Many students developed schematic machines for the 3D printing of various objects, but many of the more sophisticated proposals involved almost relatively basic technologies such as CNC knife cutting, vacuum casting and press casting. Three examples shown below demonstrate these approaches. The first, by Jan Rose, is a service by which children can recycle paper waste into toys – cast into shape using a vacuum casting process. The images show the testing undertaken to determine the most stable mixture of paper pulp and integration of mesh mould. The second, by James Henderson shows a process through which lettering and signage might be permanently cast using a CNC process. The last, by Jy-Yeon Suh demonstrates how coffee grounds might be reincorporated into a coffee-shop experience as an insulating sleeve and thereafter as a composting plant pot. These examples, along with the others created in response to the brief are a good illustration of the vast potential for the role of automated craft, and the strong link between these approaches and the discipline of Industrial Design which can give form and meaning to such processes with a suitable audience or market in mind.



Jan Rose, Paper Pulp forming machine



James Henderson – Concrete Printing Process



Jy-Yeon Suh – Multiple Re-Use of Coffee Ground waste

The fact that some of the most successful examples from the project make use of relatively familiar technologies and a hands-on crafts approach is a good demonstration of the complexity of the argument surrounding the two. Another good illustration of this is the Pixel Casting Machine by Julian Bond. For his second year project at the Royal College of Art, Bond created a series of machines which appear to remove some of the craftsmanship in processes closely linked to hand-making. The handmade nature of the machines, however, and the evident skill required to operate them indicates the difficulty in drawing clear lines between automation and craft. The Pixel Casting Machine enables its users to create infinitely variable shapes of vessels, based on a matrix of rods which can be adjusted in the slip-casting mould. While the name suggests otherwise, this is a long way from a high-tech process, but the accessibility of the adjustment process and room for user-manipulation definitely lends a degree of automation.

Pixel Casting Machine by Julian Bond   Pixel Cast Vessels by Julian Bond

A second project, by Dejan Mitrovic, also from the Royal College of Art, shows how a more high-tech approach might be integrated into a teaching tool. Through the manipulation of a basic 3d modeling interface, kids could create characters of their own design onscreen that could then be output by a basic 3d printing machine and then assembled by hand.

Kide Robots by Dejan Mitrovic

Conclusion

The development of rapid prototyping technologies for manufacture, whilst apparently a high-tech pursuit, has, in the first instance, found a disproportionately large audience in the area of craft. This sits uncomfortably with the image of the craftsman as a backward-looking revivalist with Luddite tendencies, and does not seem to have been supported wholeheartedly by the 'official' gatekeepers of craft practice such as the Crafts Council in the UK. Nevertheless, the potential of these processes has been wholeheartedly embraced in disciplines such as furniture design, jewellery design, ceramics and textiles and is, one suspects, entirely in-line with the ever-shifting and evolving definition of Craft. The continual tension between hand-making and automation is more evident here than anywhere else. This is precisely because the techniques and processes of automation have become available to craft practitioners of relatively modest means. One evident conclusion is that it is these practitioners, working so closely in the material of their choice, have the best position from which to assess the potential of new ways of cutting, forming, moulding, sculpting. While certain areas of craft practice have found a use for established prototyping technologies in their work, the interface, cost and availability has restricted their use to those with a specialist interest. Bringing such technologies to a wider, more mainstream audience requires a more detailed analysis of what kind of product or service is really appropriate. Industrial Design, with its focus on user experience, technology and interface, is a discipline well suited to exploring this problem. Removing the constraints or boundaries of existing process and giving the freedom to re-imagine whole new families of products helped a group of Masters Industrial Design students to develop some highly credible and innovative proposals.

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