IDEN
ISSUE 02
MAKE
INDUSTRIAL DESIGN EDUCATORS NETWORK
EDITED BY BERTO PANDOLFO AND MILES PARK
Editorial

This issue focuses on making in Australia and New Zealand industrial design research and educational contexts. Making in design is not only a legitimate and necessary activity, but also an essential and intrinsic part of being a designer. Making is learning by doing, for example, understanding material qualities through using, shaping and experiencing properties in a tangible way. Making is exploring form not just by a screen or a sheet of paper, but also ‘handling’ form and scale to other things in an environment. This is important to designers, because ultimately, what is being designed matters to the users.

Making occurs at any stage throughout the design process. From initial explorations of materials and purpose, iterations of product form, functional mock-ups and testing, through to realistic appearance models, fully functional prototypes and ultimately the finished product. Many designers ‘make to think’, by integrating model making seamlessly with desk and digitally based design activities such as drawing and CAD. Affordable and readily available digital technologies, such as Laser cutters, 3D printers and CNC routers, hasten the bridging of abstract digital design space, which consumes the attention of so many design students, and the physical world through the making. These technologies provide opportunities for new forms of making.

Making and mock-ups are being applied much earlier in the design process to help define, explore and communicate work in collaborative and cross-functional teams including, most importantly, end-users. Making is also being recognised as being increasingly important as a pre-design activity. It can assist in framing design problems and understand design possibilities before the commencement of a design project.

It is interesting to note that the peer reviewed paper section for this edition exclusively deals with digital making techniques and how these can be used to add to and alter traditional making. In both peer-reviewed papers in this edition
of IDEN there is an expectation that these new digital techniques will re-invigorate making practices in design education. Traditional design making practices involve tools, materials, facilities and trained personnel and health and safety requirements that make the provision of such activities in educational settings costly. Digital making is suggested as a means to provide a way out of this impasse.

Jennifer Loy and Samuel Canning’s paper Reconnecting Through Digital Making provides an argument that digital making can re-invigorate learning by making. Defending making and Design against the push, to move towards predominant lecture delivery and studio desk based activities, through virtual rather than physical making. They challenge that Web 2.0 through its interactive online facilities contributes toward exclusive virtual making and instead can help revive the making tradition, just as the first cohorts of digital native high school students arrive at our universities.

Miles Park’s paper Enabling Technologies: The Promise Of Low-Cost D.I.Y. 3D Printing investigates how low-cost 3D printers can not only complement high-end 3D printing and traditional model making, but also engage a wider community of non-professional designers and makers. His case study of commissioning a low-cost kit based 3D printer discusses practical considerations for reconnecting students to making in an educational setting. Introducing low-cost 3D printers can offer new making opportunities earlier in the design process through integrating existing digital design tools.

Making also has an important role within academic Design Research. Peter Schumacher offers an outline of his recently completed PhD, titled, The Design of Pictorial Assembly Instructions. He outlines the role of making in order to test research finding with various stakeholders.

The discussion of making, in this issue, emphasises various roles of making within Industrial Design, Design Education and Design Research. Making, especially designerly ways of making, sets us apart and often differentiates Designers from other making disciplines. We make things as a part of the process. As such, making things is often iterative and explorative and is very different to the making of a one-off artefact as the final action of a creative process.

The discussion of making, in this issue, is a step towards ensuring that the quality of our material world is improving in all aspects. I hope it is also a step towards further discussions for designers to critically engage with the designed object itself. Objects have actions and cultural meaning inscribed in them that direct and allow us certain behaviours and how to perform certain tasks. As designers we inscribe knowledge and, arguably, meaning into the things that make up our manufactured material world. As agents contributing to the materiality of life, I find myself surprised (or I might simply just be unaware) that there is so little scholarly discussion within our discipline about the things we make and their socio-technological resonances. We often discuss how we make things, the methods, processes and technologies, but unless we are design historians we seldom discuss the meaning, agency or socio-technological significance of the final product and its fit within our complex world. It is often, as if, the final product only exists within a vacuum or not at all. Perhaps its a case of it is ‘the journey, and not the arrival at ‘the destination’ that is so important to us?

Yet, products are discussed and critiqued all the time, but not adequately from within Design. For example, the social sciences discuss products from a perspective of how they affect culture, economists discuss products through the lens of the market, and consumer advocate groups, like Choice Australia, review and compare products against consumer criteria. In the design press it is often the glossy hero shots of the product or interview of the designer that gets the attention. But where is there a deeper discussion in the design press about the product, where agendas are often about selling and promotion. Our world of products I think deserves, especially from us their creators, a scholarly discussion about the fruits of our labour.

CHRISTIAN TIETZ
University of Western Sydney
tt@designlab.com.au


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As design researchers and educators we often become informal curators, in that we collect things for teaching, research, inspiration, curiosity or just to fill up the lost corners in our office or studio. Throughout this issue we will feature examples of products from two collections. Andrew Fowkes (Industrial Design UNSW) collects and curates an evolving informal product design collection that is displayed on a rotational basis throughout the Faculty. A very different type of collection is Berto Pandolfo’s power tool collection at UTS. His growing collection focuses upon Australian manufactured power drills. The collection is the underpinning of his doctoral research into the emergence Australia’s post-war manufacturing capacity and DIY practices.

Both collections exist for different reasons but are unified in their pursuit to capture and preserve products of distinction for educational and research purposes.

Lightburn K14 manufactured by Lightburn in South Australia, 1962

Mastermatic by Sher, VIC, an early example of combined aluminium and plastic housing
Reconnecting Through Digital Making

JENNIFER LOY AND SAMUEL CANNING
GRIFFITH UNIVERSITY, 2013

INTRODUCTION: LEARNING BY MAKING

“Making stuff” in an educational setting has been an integral part of learning for Product Design since programs were first developed. Sketch modelling and prototype making have been fundamental to the working practice of professional product designers and degree programs have traditionally emulated this practice. The value of learning by making and project-based learning has long been identified for applied design disciplines, from Fashion to Architecture.  

Even so, there have been growing financial and health and safety pressures to move programs away from hands-on workshop practice and learning by making to purely lecture and studio based programs with virtual rather than physical modelling.

There is, however, a generation of unlikely savours of workshop practice emerging. The latest cohort of high school leavers was born after the growth of the Internet in the mid nineties. These ‘digital natives’ have grown up with their teenage years predominantly spent in a digital environment. A further move from workshop practice to computer based visual modelling could be expected with this generation of students. However, new forms of design practice and digital making have developed alongside the burgeoning digital environment of Web 2.0 (interactive online facilities such as Wikipedia) that are challenging that assumption. This article considers the background to these changes and provides an example of practice supporting the argument that a re-invigoration of learning by making can occur in Product Design education through digital making.

A CULTURE OF DISCONNECT TO OBJECTS

Current high school students have life experiences dominated by online and virtual activities in ways that could not have been predicted.  

1. Tweeting, texting, You Tube, multiplayer online gaming and that instinctive recourse to the Internet as the primary source of information and communication have changed their understandings and everyday practices in comparison to previous generations. This immersion in the virtual world could, theoretically, be causing these embryonic adults to become disconnected from the meanings and mechanisms of their physical environment.

In addition, Australian products are predominantly made in distant places, ways that are unseen to the average school leaver, in a mass production system beyond their comprehension. The studio culture has arguably not evolved in step with this intent. Meanwhile, computer learning labs and interactive online facilities such as Wikipedia must all turn to the crafts’ source of information and communication.

2. Current commercial products are rarely designed to be repaired because of that distance from production, the influence of individual consumers. Reducing learning by making in Product Design education is likely to contribute to this design trend.

A CULTURE OF DISCONNECT IN THE LEARNING ENVIRONMENT

Design is described as an iterative process developed through exploration, research, sketching, studio modelling, idea development, testing and prototyping as a seamless experience, with the ability to move between techniques and approaches to inspire, inform, develop and validate as necessary.  

Yet the learning environment for Product Design in higher education has arguably not evolved in step with this intent. The studio culture has receded in many Australian Universities in favour of either a ‘hot desking’ approach (where students place impersonal work spaces on an ad hoc basis) due to increased numbers, or a transient classroom, booked for contact hours only. At the same time, workshops are in danger of becoming over controlled spaces, discouraging experimentation, as risk management requires increased supervision by academics and pressures on the curriculum reduce the time available for students to gain sufficient skills to work to a standard unaided. Meanwhile, computer learning labs have come into being over the last twenty years and although they are heavily utilised,
their design as learning spaces is rarely thought through further than rows of computers with a large screen at one end of the room. Computer aided design was initially seen by students as supplementing studio and workshop practice, but the quality of 3D modelling software and the rendering capability now is such that some students no longer understand the need to make physical models to communicate their design ideas. Worse, lecturers drawn to projects that are provocations, or based in an abstracted reality, can be equally seduced by the virtual world, valuing only the concept phase of a design project and stopping short of any practical realisation or testing of ideas that is regarded as fundamental to design development in the working practice of leading professional designers.8 Without that design development anchored in the reality of making, design stops short at an early concept stage of development, with the iterative practical development stage, where design ideas are fed by directed research into materials, processes, production, ergonomics etc, ignored. Design becomes a diluted discipline that ‘anyone can do’, without a valued body of knowledge, invaded by the humanities and in danger of becoming a transferable skill of ‘design thinking’ across multiple unrelated disciplines with the associated concerns raised by Crisp7 and Loy9.

RECONNECTING THROUGH DIGITAL MAKING

Contrary to what could be expected with the rise of the Internet and the virtual environment, the Maker Society, as defined by Anderson in his book Makers: The new industrial revolution:10 has not been killed off by the digital, but in contrast is experiencing a resurgence led by increased communication through Web 2.0 and new digital making opportunities. An example of this phenomenon has been the rise of the networked FabLabs.11 These were an initiative by Neil Gershenfeld, the Director of the MIT Centre for Bits and Atoms, to provide open access to high technology digital making equipment. Initially set up as an experiment to meet his academic requirement for community engagement, this project has spread throughout the world, with 117 registered sites predominantly in Europe and America (plus officially in this part of the world one in Wellington and one planned to be opened in Brisbane in July) with some of the most innovative projects coming out of FabLabs in more remote locations, such as Afghanistan. CNC routering, laser cutting, digital embroidery, electronics and 3D printing (the common term for a range of additive manufacturing technologies) are provided in a FabLab. Gershenfeld suggests that the digital basis for the making facilities on offer reconnects the two worlds, digital and physical.

This link between screen and reality provides an opportunity to engage higher education students with making again. Advanced technology machinery can be installed in a University studio environment, rather than in a separate workshop. A studio equipped with computers and digital fabrication machinery changes the relationship of students to making, meeting them in a familiar space and building on their CAD modelling skills. Once their confidence is increased through digital making, they can then transition to a conventional workshop more easily. Subtractive digital technology (CNC and laser cutting) for digital making has been available in education for over a decade, but it is the 3D printer, directly linked to their comfort zone and translating the proficiency that digital natives demonstrate in 3D CAD modelling, that empowers the student and changes their relationship with the objects and mechanisms of their physical environment.

With this potential, it could be expected that Product Design educators would be at the forefront of driving additive manufacturing into the curriculum at every opportunity. Yet from a learning by making standpoint, if the hype on 3D printing was to be believed so that ‘anything’ could be printed and that complexity came ‘for free’ and that the build of support scaffolding was left to hidden agency in proprietary software, then the ‘push button’ making it provided would actually add to the disconnect between students and making, not address it. In reality,
additive manufacturing, in all its forms, has as many constraints and design considerations as any other production process, as outlined by Gibson et al.3 Educators have been exploring those realities themselves, as demonstrated by the Royal College of Art project in 2007 to challenge leading designers to ‘mould the unmouldable’13 and introducing projects addressing specific technologies, such as the University of Technology, Sydney’s Digifracture project on selective laser sintering.14 But, just as a drive for the uptake of 3D printing worldwide has come from the general public with over 300,000 designs uploaded on the hobbyist online service provider Shapeways, so too has there been a drive to bring digital making into learning by making in Product Design education from the students themselves.

Example of Practice: Digital Making in the Curriculum

The cost of stereo lithography for rapid prototyping over the last fifteen years meant that additive manufacturing was generally confined to research and postgraduate work in Product Design at Griffith University until a few years ago. Since then fused deposition modellers (class size with soluble support material and desk top with same support material) have become affordable for the classroom (RMIT, for example, have a personal 3D printer attached to each computer in their technology teaching space) but only a few universities, such as Auckland University of Technology, as yet have a selective laser sintering machine in house. In 2008 the Dutch company Shapeways launched an online 3D printing service that provided subsidised printing, introducing nylon products in 2009 and metals and ceramics since. In four years they have printed over a million objects and been joined by several other online service providers, such as materialise, and it is these services that has enabled a democratised uptake of digital making in undergraduate education.

In 2010 third year students at QCA Griffith University studying Product Design started using Shapeways to 3D print their prototypes across projects. Until then, visual models were limited to foam models they could produce in the workshop and mechanisms tested were confined to working models they could produce or expensive samples they had made by a specialist, usually only for a competition. With the newly competitive online service providers, students were able to produce effective working prototypes of small items that were inexpensive enough to be developed—through several iterations if necessary—to achieve viable designs. This work was characterised by being prototypes with production detailing such as parting lines and draft angles as illustrated in figure 1 and 2.

In 2011, second year students were given a packaging project based on fused deposition modelling. The students were asked to produce a point of sale perfume display as part of their assessment where the bottle forms they produced would inform the final mass-produced bottles. Whilst students still predominantly thought of conventional manufacturing terms, there were examples of objects that could not have been produced by techniques requiring male and female moulds. In addition, released from making the difficulties of making complex models in foam, students produced forms they would struggle to construct otherwise.

The creative potential for artistic work demonstrated by the work led to a collaborative 3D printing project where a postgraduate created a leather headpiece then translated by lecturers (authors Loy and Canning) into CAD suitable for printing. The finished item was exhibited at the Materialise conference, Belgium and Rapid conference, USA.

These activities demonstrated a potential for the development of new forms and ways of thinking, but the second year students involved had studied processes and materials in the first year and still came to the project from a starting point of conventional manufacturing.

A component approach was even clearer in the headpiece—although the product was not, and was never going to be, made in...
components that was how it was modelled because of the mass production experience that informed the lecturers’ thinking. Just as professional designers have tended to approach additive manufacturing as a replacement for other polymer processing techniques, so too will lecturers, such as the authors, whose careers have been built in the conventional manufacturing environment. Professional development opportunities are needed to make that transition in thinking to explore the potential of 3D printing. To understand and anticipate the opportunities for future graduates emerging through the digital environment, from screen to reality, is a challenge. This is illustrated by considering the changes in Product Design practice over the last four years—the length of an Honours degree—through the digital environment. The rise in crowd sourcing in Product Design, for example, as used by leading design consultancy IDEO and the introduction on online mass customization, championed by Assa Ashuach with the co-design web site UCODO and developed with Lisa Harouni through the company Digital Forming, both change the way Product Designers in the future can interact with users and impact on Product Design education. Manufacturers who have been able to exploit the advantages of additive manufacturing by working with organisations with an in-depth knowledge of the technologies, such as hearing aid manufacturers Phonak working with research and development leaders Materialise, are gaining significant advantages through innovative thinking informed by understanding.

From dentures to spare parts, new ways of working through additive manufacturing allows for innovation and preparing students to graduate with an understanding of that potential in four years time requires a reevaluation of educational practice. Based on this thinking, the decision was made that additive manufacturing would become the first manufacturing process the students would learn when they started their degree. The first year processes and materials course, introducing workshop practice, was turned on its head with additive manufacturing the first process students experienced, with established production methods, such as injection moulding, then introduced in comparison, rather than the other way around. The packaging project was brought into the first year, with the added proposal that the client had asked if the bottle could be produced using 3D printing for a short run, niche market.

In addition to the point of sale display, students were required to research a report on the viability of that proposal in comparison to using more conventional processes and outline the considerations for the client. The first year CAD course was rewritten, ramping up learning to allow students to model their own designs by the end of the semester.

To connect studio design, CAD and digital making for a more iterative process, students worked in an advanced technology studio environment that combined computers, table space for drawing and sketch modelling, an enclosed CNC router, A3 laser cutter and desktop 3D printer to encourage an integration of computer modelling, studio design development and digital making. Although the class sized fused deposition modeller was available, students were encouraged to first gain hands on experience of the more accessible digital fabrication equipment. The project work was student led, where they mapped what had to be done, their risk assessment, brought in materials, created CAD drawings and made test cuts and 3D prints as they saw fit (Figure 10 and 11). A woodwork workshop was immediately next door and students had the option of being inducted into using some of the machinery and hand tools in there and were actively encouraged to use the bench spaces for jig making. Once the students were comfortable in the mixed environment, they
were then given a demonstration of vacuum forming in the plastics workshop and shown strip heaters. They were encouraged to make foam formers for the vacuum former and create inserts for their packaging to fit their designs.

Based on student feedback, the biggest difference in working this way to introduce a cohort from the ‘digital native’ generation to workshop practice and learning by making was that they felt empowered by the learning experience and not frustrated by the standard of work they were able to produce, as had been the feedback on the workshop component of the course in previous years. Student evaluations gave the course overall positive feedback and from a lecturer point of view, the positive experience of having to prise students out of the workshops hours after the contact time reinforced the value of learning by making in the current curriculum, adapted to encompass digital making, not in conflict with it. The student work was made to a sufficient production standard not in conflict with it. The student work was made to a sufficient production standard that it could be included in the exhibition that accompanied the 3D printing forum organised by the authors at Griffith in conjunction with Materialise Europe, QMI and The Edge alongside work from postgraduates and leading European designers.

**CONCLUSION: DIGITAL MAKING AND INDUSTRIAL REVOLUTION 2.0**

Additive manufacturing has only had viable direct manufacturing capability in the last five years. Already it is impacting a broad range of industries, from medical to automotive. In each case, it is the customisation potential that creates new ways of approaching product design. The sustainability imperative requires greater accountability in design and production, with product service systems thinking and invested design principles driving the redesign of products. UK Designer and Commentator, Geoff Hollington, suggests that the dominance of mass production is being challenged by the potential of additive manufacturing as a transformative technology with the potential to transform both the global economy and the consumer society. Digital natives are using Web 2.0 as pro-sumers or co-consumers in increasing numbers, rather than as the passive recipients of anonymous product. The first industrial revolution has even been described as a ‘temporary interlude’ if distributed manufacturing again becomes prevalent and demand for mass customisation replaces mass production.

The teaching and research advantage for Product Design Educators of the social revolution aspects of Additive Manufacturing is that the impacts touch on vital areas of consumption, socio-cultural sustainability, urban planning and regional economic development with extensive literature on the subjects, for example in the collected essays in Open Design Now, the essay by Atkinson of particular relevance. Teaching additive manufacturing will not be like teaching other production processes. Product Design students need to graduate into the digital world grounded in the physical world, with an evolving understanding of the context they operate in. They need to be prepared to lead the redevelopment of consumer products within the sustainability imperative and be equipped to make a living within the profession whilst influencing the changing production landscape positively with informed thinking and practice. The digital realm may have contributed to the alienation of the younger generation to the built environment, but conventional production methods had the major effect in creating low value, disconnected products. There are examples of designs that contribute to a reconnection of users with the mechanisms of products (for example in the transparency of the working of the Dyson cyclone vacuum), but this needs to go further for product service systems to be effective, with design for disassembly and repair fundamental for future products. Additive manufacturing, with personal printing and distributed manufacturing has the potential to make that a reality. Embracing it as a driver for learning by making for grounded, reality based projects reconnects future product designers to the objects they design and supports a positive future in a digital realm beyond current understanding.

JENNIFER LOY AND SAMUEL CANNING
KBC was a manufacturing company that operated out of Woodlands, Adelaide, South Australia. This drill was first made in 1948.

U-500, Black and Decker. This was the first drill to be completely manufactured in Australia at the Croydon factory in Victoria, 1957.
Enabling Technologies: The Promise of Low Cost DIY 3D Printing

MILES PARK
UNIVERSITY OF NSW, 2013

ABSTRACT

This paper investigates recent developments in low-cost 3D printing and offers a case study on the practicalities of commissioning a low-cost, kit-based 3D printer. It discusses a range of practical considerations and possibilities on how it can assist in reconnecting students to making in an educational setting. The promise of digitally printed parts and models from an affordable desktop machine has many perceived advantages in complementing the more established 3D machine as an open source DIY project. In addition, low-cost 3D printers have opened up new making possibilities for a wider community of non-professional designers and makers. In design education settings the integration of low-cost 3D printers can offer new making opportunities earlier in the design process by integrating with existing digital design tools.

INTRODUCTION

3D printing, along with other digital making technologies, capture an emerging theme for the 21st Century—a biological century where things are ‘grown’, unlike the ‘heat, beat and treat’ manufacturing processes of past centuries. Many designers and makers have eagerly awaited the relatively recent availability of low-cost DIY 3D printers. 3D printing fits within an evolving ecosystem of low-cost design and prototyping enabling technologies. This includes, in addition to 3D printers, 3D scanners, laser cutters, CNC routers and simple to program devices (such as, Arduino, Raspberry Pi and Twine). These tools bring enormous creative opportunities to designers, students, design educators and individual makers enabling them to experiment and create technically advanced outcomes. The affordability and availability of these enabling technologies democratises ownership and redistributes access to sophisticated equipment that has, until relatively recently, remained the domain of large organisations or the well resourced. Some claim 3D printing and associated technologies are nothing short of a ‘third industrial revolution’, disruptive and revolutionary Others take a more precautionary approach that 3D printing is still at an early stage with hackers and early adopters still figuring out what to do with it. While much attention has been focused upon the possibilities of what digital disruptive technologies can offer in transforming aspects of design, making practices and manufacturing, the depth of this transformation remains speculative. It is still at a relatively early stage of development. The emerging possibilities of 3D printing and allied technologies are akin to the early days of rapid technological and market development of the Personal Computer during the 1980s. As such, the experiences of users are usually mixed and often depend upon technical aptitude, knowledge of 3D CAD and realistic expectations. To ‘print’ a 3D CAD file is inherently more complex than the ubiquitousness of process of printing a paper document. Their portability makes them ideal for student use, university open days and recruitment events. Their low-costs enables student ownership, and their flexibility enables them to be modified, upgraded and repaired.

RISE OF THE MACHINES — THE ARRIVAL OF LOW-COST 3D PRINTING

Within the last year alone there has been a dramatic increase in the availability of low-cost 3D printing machines. These machines can be defined as costing less than $4000 (USD) and generally marketed to individual users who do not require high frequency use or high performance materials. The explosion and, to some degree hype, around 3D printing has been remarkable. Not least because it is less than ten years since the availability of the first low-cost 3D printing machine as an open source DIY project. The ‘self-replicating rapid prototype’, or RepRap advanced early research into low-cost 3D printing. Its developer, Adrian Bower from Bath University, UK, conceived it as a machine that could print and self-replicate its own parts from downloadable files. He envisioned a system that enabled communities around the world to ultimately bypass traditional manufacturing and
distribution structures. By 2007 RepRap and Fab@home, another open source 3D project, became available as a kit of parts and self-assembly instructions. These kits required a degree of technical competency to construct, commission and operate. The first truly self-assembly kit based 3D printers, the CupCake, and soon after the Thing-O-Matic both developed by MakerBot Industries in the US, only became commercially available in 2010. In parallel, MakerBot launched a website—Thingiverse. The service offers contributors to upload STL CAD files to share and remix design files for use on a variety of digital making machines; not dissimilar to music file sharing services such as Soundcloud. Another service, Shapeways offers an alternative model where uploaded files of a design, typically, design prototypes, sculptural and jewellery pieces, gadgets for technologies and hobbies, can be purchased and dispatched as printed objects in a selection of materials.

Since 2010, many other low-cost 3D printing machines have been launched into the market. A recent estimate (January 2013) found that there are in excess of twenty commercially available low-cost 3D printing machines with at least another half a dozen machines close to market. A number of the latest crop of low-cost 3D printing machines are still emerging from open source community start-ups offering an array of options from kit build to ‘out of box’ ready built solutions.

**PRINTING TECHNOLOGY**

Most low-cost 3D printers utilise a printing method based upon fused deposition modelling (FDM). This is achieved by feeding PLA or ABS plastic filament through a precisely located heated nozzle that extrudes a thin stream of material to build up successive layers of plastic into a 3D object. These machines do not, yet, offer the tight tolerances, reliable finish resolution or material performance of their larger and more expensive industrial counterparts. Incumbent 3D vendors, who have traditionally supplied ‘high end’ rapid prototyping 3D printing technologies for industry, are also moving into the low-cost 3D printing space. 3D Systems, the developer of Stereolithography, is one of the first commercial 3D printing technologies claim to offer ‘plug and play simplicity’ with their low-cost ‘Cubify’ FDM printer. Conversely, another but much lower-cost stereolithography machine has recently been launched. The ‘Form One’ 3D printer is touted as an affordable, high-resolution 3D printer. It was developed at the MIT Media Lab and raised over $2 million (US) on the crowd-funding platform Kickstarter. However despite positive reports emanating from the technology press, the Form One start-up and Kickstarter have been challenged for an alleged patent infringement by, unsurprisingly, 3D Systems the developer of Stereolithography. Given the open source structure for a significant number of the low-cost 3D printer start-ups, the prospect of infringing intellectual property seems an anathema to the many advocates for low-cost 3D printing and the collaborative nature of the communities behind the technologies.

**LOW-COST 3D PRINTING IN PRACTICE**

As a means to develop a greater understanding of the opportunities for low-cost 3D printing for design education, a research project commenced mid-2012 to evaluate of a ‘representative’ low-cost 3D printer. The research investigated utility, practicalities of commissioning and using a machine for student use. The printer chosen for the task was the Ultimaker 3D Printer. This kit based machine became available in the second half of 2011. The machine is reliant upon open source hardware (Arduinio), standardised components (stepper motors and bearings) and is fabricated out of laser-cut plywood. A key feature is a low-mass ‘hot end’ extruder that is claimed to enable fast and accurate printing.

“Why did we choose the Ultimaker? We considered many different models ... MakerBot Replicator, the Bits from Bytes 3D Touch, the PnP Up! and the 3D Systems Cube ... we concluded that it wasn’t a practical requirement for the average student. Instead we focused on the three main attributes we judged as important for common use: print quality, speed and cost. The Ultimaker surprisingly came first in all of these key attributes by quite a large margin. It was therefore an easy choice as our test machine. More on these attributes as we begin testing.”

JOSH FLOWERS, STUDENT RESEARCH ASSISTANT

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CONSTRUCTION AND COMMISSIONING

The kit requires approximately 16 hours to construct and is supported by an online wiki instructions with various tips, updates, and improvements offered by users. This part of the process was relatively straightforward. A time-lapse film was made documenting the construction. With the construction complete, initial tests revealed a fault with the extrusion mechanism that was traced to a faulty main circuit board. With a new replacement circuit board and a firmware upgrade, the first test prints were achieved. Initial results were crude but looked promising. Necessary adjustments to the tension of the belts and extruder head travel end-stops would enable more accurate printing; however, this was not a straightforward matter.

“First step: tighten the belts! If the belts are loose (and they were) the print head responds sluggishly and with less accuracy … but there was no simple way to tighten the larger axis belts on the Ultimaker without getting really fiddly. I ended up printing the solution using a pre-made design from Thingiverse. They are tiny clips that fit on the edges of the existing belt support blocks. Incredibly simple, yet effective!”

JOSH FLOWERS, STUDENT RESEARCH ASSISTANT

Further test prints still failed to achieve a successfully complete print. The problems encountered involved the hot-end and extruder feed mechanism causing filament slippage and blockages. Many workarounds were devised leaving us to conclude that the current extrusion mechanism is clearly not fit for purpose. Around this time Ultimaker released an improved extruder heater nozzle (Hot-end):

“The release of a revised hot-end by Ultimaker is significant for two reasons; first it shows that they have acknowledged the poor design of the original, and second it means we’ll hopefully be printing without blockages very soon!”

JOSH FLOWERS, STUDENT RESEARCH ASSISTANT

With the hot-end assembly problem solved, attention shifted to the other half of the problem—the extruder feed mechanism. The solution was to rebuild an entire new feed mechanism based upon a design posted on the Ultimaker forum. This required the printing of new ‘replicated’ parts from downloaded STL files.

“In preparation for the overhaul of the extruder, I researched all the viable alternatives. Dozens of fixes have been suggested and posted in the Ultimaker forums … The challenge was to get the unreliable Ultimaker to print the parts, but with many failed attempts and some luck—it worked!”

JOSH FLOWERS, STUDENT RESEARCH ASSISTANT

After these setbacks were resolved, the machine was finally calibrated and ready to print a series of test pieces. This involved printing simple and complicated forms with a range of different settings to understand the capabilities and limitations of the machine. The most challenging task thrown at the machine was to print an interlinking chainmail. Critical to the success of any print is preparation of the machine. Belts, hot-end, and filament feed require regular maintenance.
inspection. The print bed has to be taped, cleaned and levelled on a regular basis to ensure the correct amount of adhesion for the first print layers. An out of calibration machine will at best print distorted parts, out of tolerance, and at worst result in a clogged hot-end with a solidified lump of plastic spaghetti welded to the bed.

**DESIGN PREPARATION AND WORKFLOW**

In addition to resolving the mechanical side of 3D printing, file preparation is a key element of the process. The digital workflow for 3D printing commences with the preparation and export of a STL file from a 3D design software package. This is then imported into a slicing software package to produce numerical control (NC) programming language known as G-code. It is G-code that determines all dimensional (x,y,z axis) movements and machine settings such as nozzle temperature, print speed, layer height and filament feed, retraction and so on.

A primary consideration for a successful print is part design. As with other plastics manufacturing technologies, 3D printing has its own unique part design requirements. Part design considerations will also vary depending upon which slicing software and printer is used. The primary design variables are:

► Wall thickness—including top and bottom layers that can be independently specified
► Fill density—specified as a percentage of material density of the part cavity
► Support and Raft—creates support structures to prevent warping

**LIFE IN BETA**

It is not unreasonable to claim that the experiences described above are typical in assembling and commissioning a low-cost 3D printer. They are broadly representative of the experiences many users have encountered. This is evident from the number of blog and forum posts that either request help or offer tips and solutions. Periodically vendors will offer upgrades and revisions for their machines. For example, in late 2012 a new extruder nozzle assembly (hot end bundle) was offered for the Ultimaker for their machines. For example, in late 2012 a new extruder nozzle assembly (hot end bundle) was offered for the Ultimaker in acknowledgement of an ongoing problem with nozzle blockages and leakages in response to the many forums posts on the problem. This is not so surprising as so many machines are new to market and remain a perpetual state of developmental evolution—akin to the state of beta issued software. There exists a spirit of ‘work in progress’ to which users, posting on various online forums, play an important and influential role in providing feedback and guidance for ongoing design development. This demonstrates a key attribute of the open source ethos that many low-cost printer start-ups and their supporters embrace.

**DESIGN EDUCATION STUDIO**

In an industrial design studio setting an obvious benefit of low-cost 3D printing is as a supplementary, ready-at-hand, tool for model making tasks. Its affordability and portability offer an immediacy to design projects where low-cost printers can be located in the studio, adjacent making spaces or even student’s personal study areas. Such arrangements enable design student to prepare and produce printed artefacts earlier in the design process where iterative, explorative and experimental design activities are encouraged. Model making early in the design process is a valuable and often necessary exercise as a means for the designer to ‘build to think’ through a design. This early experimental modelling stage is well suited for low-cost 3D printing where surface finish, colour and materials are not necessarily important. For example, concept models of control knob variants for a kitchen cooktop/hotplate design enable the designer to explore product forms to resolve aesthetic and ergonomic matters. As well, multiple prints of a control knob design can enable user testing of control function and spatial arrangement, such as cognitive mapping of which knob should go where. In a design studio setting, low-cost 3D printing can offer:

► Proof of concept—demonstrate physical functionality
► Ergonomic and aesthetic assessment of physical form
► Parts for user-centred design research tasks—user testing and prototyping experience
► Test parts—fit, interference and nesting with proprietary parts
► Duplication of parts—repetition of similar parts for assembly onto a model
► Incremental part variation—concept design variation
For final ‘appearance models’ 3D printed parts require a degree of finishing and post processing. Surface stepping needs to be removed through controlled sanding prior to painting with an appropriate primer and topcoat. Gluing printed parts together also requires knowledge and planning with ABS offering superior qualities over PLA.

Other project opportunities for low-cost 3D printing in the design studio could be framed around themes such as utilisation of additive manufacturing technologies, electronics and mechanics, part fit and tolerances, up-cycling and working in teams. For example, studio projects devised to build an open-source 3D printer in teams from obsolete inkjet printers or assemble and commission kit based printers.

RECONNECTING WITH MAKING

Workshop traditions and student expectations still often place model-making as a final stage event in design projects with the creation of a ‘appearance model’. This is despite the increasing capability and ease for computer visualisation to fulfil a similar role. For many design students the computer has become the primary tool platform for design activity. As such, the role of making, to test and develop a design is often neglected and seen by design students as unnecessary extra work. Low-cost 3D printing offers a means to short-circuit these entrenched practices by uniting the predominance of screen based virtual design with the ‘made’ material world. It can assist in developing a fluidity of a back and forth workflow between digital design and physical modelling; it enables an experimental and iterative design process by offering physical feedback of the virtual design space of CAD.

WORKSHOP RESOURCES

For educational institutions the adoption and distributed ownership of low-cost 3D printers can reduce demand for specialist workshop equipment that is often under utilised. For example, model-making tasks that require milling and lathing tasks can, in certain instances, be achieved by 3D printing that can take place in spaces other than the workshop. This can reduce unmet demand by students and refresh training on equipment that may only be used intermittently. This reduces the burden of technician support in safety compliance, training and supervision. However, it must be stressed that this is not an excuse to diminish the importance of accessible workshop environments as a rich and vital contribution to a design education. If workshops can resist the temptation of expanding their suite of digital making technologies with their finite resources they will be able to better focus on creating an accessible workshop environments for existing students model-making needs. As digital making technologies increasingly become located in office or studio environments, it makes economic as well as pedagogical sense to empower students with these increasingly low-cost technologies through direct ownership or ready availability in the design studio where most design activity takes place. We are already seeing the seeds of distributed ownership with the emergence of student 3D Printing user groups and individual ownership of machines by staff and students.

CONCLUSION

Low-cost 3D printing offers an engaging and affordable making platform for design creativity and problem solving. For the design student, it can reconnect the preoccupying virtual world of CAD design and visualisation with making. Making, at any stage during the design process is a valuable and often necessary activity. Despite the predominance of digital design environments, making remains at the core of many design practices as a means for the designer to ‘build to think’, test and verify design propositions. Low-cost 3D printing does not replace the need for the traditional workshop or ‘high-end’ 3D printing services. It fits within an evolving digital making ecosystem of increasingly affordable technologies. This evolution is far from mature as low-cost 3D printers remain temperamental and experimental devices. They cannot be left unattended and often demand a degree of technical aptitude from the operator. However, as the rollout of new machines continues unabated with improved stability, usability and printing performance for lower cost, it appears inevitable that we will see a growing student ownership and utilisation of low-cost 3D printers.

ACKNOWLEDGEMENT

Joshua Flowers for his skill and knowledge in commissioning the Ultimaker. A blog account of the project is available at http://lowcost3dprinter.wordpress.com/
The Sher Drillmaster was the first all plastic Australian drill, first produced in 1952. Notice there is an ON/OFF button to activate the drill, no trigger.

This Wolf Safetymaster was made in Australia at the Wolf manufacturing plant in Auburn, New South Wales. Wolf is a brand of power tools that originated in England.

The BD552 drill from Black and Decker was one of the last drills to be manufactured at the Croydon factory. Black and Decker cease manufacturing in Australia in the late 1980’s.
NON-PEER REVIEWED PAPERS
The following is an account of an international master of design student who had undertaken a studio with the very specific objective of designing a small object destined for the giftware/homeware market and developing it for local small batch production. The task was to be completed within a normal teaching semester and was only part of the students’ full time load. It is interesting to note that when the premise of the project is the actual production and sale of the final design rather than a final prototype, within a defined time frame, the choices and decisions made are different to those made during conventional object specific projects and therefore a new set of experiences and challenges can be experienced by the student.

"Is the shape the real aim? Or is it the result of making the shape? Is it the primary process? I don’t take position against the shape, only against the shape as an aim. I do that after experiences and certainties. The shape as an aim leads always only to formalism."  

LUDWIG MIES VAN DER ROHE, 2010

Bowly is the result of a long making process, testing and re-making, looking for a final design that was not only innovative and looked beautiful, but was also functional. This project began with the brief for the Master of Design studio; Object and Accessories at UTS. The aim was to create a container using any type of sheet material, at first this sounded easy but for me it wasn’t. I didn’t know where to start, the field was huge and diverse and I was used to working on commission from a brief given to me by a company. I decided to experiment with materials for inspiration that could help me develop something new. The concept emerged through playing with paper and cardboard. I was interested in the challenge to create two opposing concave surfaces by simply cutting and bending the shape from the same sheet, and forcing the material in opposite directions.

I needed to use simple geometric forms to enable me to make modifications and/or changes as the project moved forward. I choose circles as my starting point. The concept is made up of three intersecting circumferences divided by lines that pass through the centre of the main circle creating a nice soft shape with no angled edges.

The next step was to start making. I made about two dozen samples using cardboard to find the best shape to model using CAD. Following the CAD stage I needed to choose a material. I thought about sheet metal, a 2mm sheet would have been the best choice and probably the easiest way to realise my concept, but I needed a challenge, to put myself to the test, so I chose 3mm plywood. I soon discovered that what I created using cardboard was not so easy with plywood.
BOWLY

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suppliers looking for a high quality plywood made up of six layers instead of only three. I felt I was getting closer to my goal.

The first plywood tests were cut by hand, I now wanted to cut the shape using a laser.

To do that, vector drawings were required. I used this opportunity to modify the diameter of the circles, and the number of the petals and finally I decided that I could obtain the best result keeping twenty petals, ten for each side.

When cutting the parts I realised the laser cutting process burnt the plywood edges. As I didn’t like that another step was added to the process, sanding the edges. Every single part must be perfect.

The length of time the plywood was left in the water and steamed was important, more so than I had initially thought. I realised that it needed to be longer as the final result still wasn’t right. Getting the plywood to bend without cracking was dependent on getting this process right. Every single part of this process that at first seemed unimportant turned out to be crucial for the project to succeed. It took a lot of effort to reach my goal, but I didn’t give up because I’d always believed in this project and I wanted to see it through.

At the end I’ve realised that to produce this design using plywood, it made the process too complicated and difficult to industrialise and finally sell. I’ve never forgotten the fact that I’m an industrial designer and not an artisan. The purpose of a good industrial designer is to be able to design and create a good idea that can be easily produced.

That’s the reason why I’ve decided to go back to my first intuition and reconsider the possibility to using metal instead of plywood. However, it was worthwhile putting myself to the test to discover new limits and abilities and learn new things and techniques.

One of the most important lessons I’ve learnt as an industrial designer is to never forget about how your idea can be produced because it is in resolving those issues that a truly resolved design can be found.

FRANCESCO PAOLO COSENTINO

I started with some scrap 3mm plywood found at the university workshop, I played with the shape using a saw and sandpaper.

Further research about techniques in bending timber was vital to move my project forward. I discovered that plywood needs to be soaked in water, steamed and then formed under pressure using a mould.

One of the most important steps and hardest part of this project was making the mould. I made several moulds as each one answered a problem uncovered during my testing. The first attempts were far from what I had predicted. Discussions with my studio leader and fellow students lead me to change plywood. I phoned many
1936 Kodak Bantam Special camera designed by Walter Dorwin Teague in the streamlining style.

1972 Panasonic wrist radio R-72 Toot-a-Loop.
Design, Production and Consumers: Exposing students to the challenge of selling their designs

BERTO PANDOLFO AND MICHAEL SAMAHA
UNIVERSITY OF TECHNOLOGY, SYDNEY

The discipline of Industrial Design is subject to the circumstances in which it functions. Allowances and constraints posed by markets, cultures, conventions and jurisdictions all compete to influence the grand narrative of design. The practitioner does not operate autonomously and awareness of their influences is vital to ensuring the relevance of their work.

For designers seeking to produce commercially viable products, a certain type of savvy is required. They must choose a market, understand that market, target that market. This awareness must enlighten the considerations, the decisions and the overall direction of the project. Even the most abstract of art is pointed. In the case of commercially viable design, the product must stay true to one of its primary goals—to sell.

Currently, the study of Industrial Design fails to provide students with a real world experience of this aspect of the process. While plenty of subjects cater to the cultivating of their conceptual practice and stylistic identity, there is a need in the ID curricula, to address this shortcoming. The Industrial Design program at the University of Technology, Sydney has initiated a series of elective subjects with the specific objective of commercialising design.

The elective subjects are available to both undergraduate and postgraduate students. The process of designing an object, producing a small run and then selling them is divided into two separate electives. The primary elective is devoted to the design and development of an object. The subject is highly prescribed, students engage in a controlled, concentrated and manageable task of producing a laser cut fruit bowl in semester one or a slip cast flower vase during semester two. Students are provided with an exact methodology as to how they should approach the task. The reasoning behind this approach is that, if students are given the autonomy of a blank canvas, free from significant prescription, their focus is directed instead to the conceptual development and worth of the object, not its real world feasibility. The scale of the object is vitally important to the success of this elective. Both the bowl and vase are contained and enable students to design and make then reflect, critique, redesign and make again. This process allows the student through numerous iterations to present a well resolved and appropriately detailed design by the end of the elective.

The follow up elective, ‘Special Industry Project: Design Enterprise’ takes the primary elective one step further by adding a more focused, manufacturing and commercial dimension. It calls on students to plan and implement the manufacture of “a batch lot of ten” of either their flower vase or fruit bowl. Additionally, they must design a brand identity, packaging, and point of sale material. Their aptitude for these dimensions is then tested in a real world scenario by attempting to sell their work. It is then the real world consumer who shall determine the success, desirability and relevance of their project.

The project brief acknowledges the deficiencies of current Industrial Design courses when it states, “Due to constraints such as time and resources it is very difficult for students of design to realistically experience industry like situations”. This is followed by outlining the intention of the ‘Special Industry Project’, when it states, “The field of product design as opposed to craft is generally concerned with multiple
or serial productions, the issues impacting a project when multiple products need to be produced are many and varied. By participating in this project some of these issues will be addressed and more importantly—experienced”.

This project is also available in the post-graduate area. Within the Masters of Design the studio Object and Accessory (O&A) is offered for interested students. In contrast to the undergraduate elective, O&A provides students with a vague brief when it invites students to begin by experimenting and investigating design solutions for an object that can be broadly classified as a container. This is because this subject does not intend to direct the embodiment of the design solution. This studio is instead calling for conceptual consideration and development to be a foundational presence throughout a students undertaking of the task. This is evidenced when the brief states, “...is aimed at encouraging experimentation; only through the physical trial and error of crafting material can we really uncover new possibilities for object design”.

However, commercial consideration remains a core aspect of this task, again from the brief, “…designing objects that are to be produced in small or limited batch quantities. Designs should aspire towards a ‘retail’ environment and not a ‘gallery’ one”. However, juxtaposed to the simplicity of the undergraduate subjects requirements, the masters studio forces students to deal with more complex pragmatic issues. This can be seen as the brief allows, “The prototype and final design are to be constructed by the designer; however the batch production that becomes sale stock should have a large component of externally sourced manufacture”. Practitioners functioning in the real world must be aware of the limitations enforced by manufacturing. A lack of awareness regarding these limitations can have dire consequences for the designer. The O&A studio requires the students to produce their small batch lot similar to the undergraduate elective and also participate in the process of selling their designs to real consumers.

The industrial design program has developed the id.shop which is the vehicle that allows students (both undergrad and post-grad) to sell their designs. The first id.shop was held in the foyer of the main UTS building in the days leading up to Christmas of 2009. Since then the id.shop has been held in private gallery’s in the Sydney CBD and the most recent was held in conjunction with the design retailer TOP 3 By Design. The objective is to expose the students to real situations, be it on campus or in large shopping centres, students are confronted and tested with their dealings and interactions with the consumer. It is important to note that not all students experience a successful sales experience, some sell out quickly, some sell a few and there have been cases of students not selling any, this too, albeit, unfortunate is a very clear reflection of what real practice can entail.

The industrial design program covers all costs associated with each undergraduate edition of the id.shop that is, all materials, laser cutting, firing, glazing etc. The products are then sold at a price that covers costs, this is a not for profit venture. This decision was taken to avoid undergraduate students having to deal with the transaction part of this process. Masters students however, are expected manage this process on their own; they are required to fund their production, determine a selling price and collect the profit from any sales.

While conceptual development and form is incredibly important, if it is unrealistic, or if it cannot manifest as a tangible thing, then its value is limited.

By calling on students to engage with the totality of the developmental process, these subjects challenge a student’s ability to amalgamate their conceptual intention with pragmatic commercial realities.

DESIGN, PRODUCTION AND CONSUMERS

Michael Potter, 2012, slip-cast ceramic flower vase
Consequently, this initiative seeks to create a more complete academic experience, providing the student with a wealth of experience and knowledge that shall ultimately assist their functioning as a practitioner of design.

The task for students to design, construct, produce then sell their design, challenges their ability to amalgamate conceptual thinking with pragmatic commercial realities.

BERTO PANDOLFO AND MICHAEL SAMAHA
1959 Braun portable record player
TP1 designed by Dieter Rams

1993 Apple Newton MessagePad 120

1985 Sony CCD-V8 Camcorder
Product Design: a course in first principles

ELIVIO BONOLLO
UNIVERSITY OF CANBERRA, 2010

Professor Livio Bonollo is emeritus professor at the University of Canberra and one of Australia’s most experienced and active design educators and PhD supervisors. His book, in full colour, is a new approach to teaching and learning product design based on a step-by-step learning program developed for students of varying educational levels. It is an easy to understand work on the design process, design language, design thinking, design methods, design skills and design knowledge. It is configured to encourage and motivate self-directed learning in design for students taking Design and Technology courses in high schools and colleges, as well as for students in TAFE, polytechnic and first and second year, university level art and design programs. It goes beyond this to also reach students and teachers in engineering and architecture courses. The book’s contents and layout reflect the teaching and learning methods in design that the author has developed over the last thirty years, firstly at RMIT, then at Monash University, the University of Canberra and universities overseas. The book is also suitable for design enthusiasts who are interested in taking self-motivated studies on an informal basis. It demystifies the design process so that practically anyone interested in design can understand and gain from the material presented which includes clearly explained case studies, an extensive bibliography and a detailed index.
Peter Schumacher, from UniSA recently successfully completed his PhD with the Australian National University, Centre of Public Awareness of Science. This piece gives a brief account of his Practice Based research titled The Design of Pictorial Assembly Instructions.

SUPERVISORS
Sue Stocklmeyer
Director
Centre for the Public Awareness of Science
David Sless
Communication Research Institute

DESCRIPTION
For a product to be useful people need the hardware and also knowledge and understanding on how to operate and maintain the product. While it is tempting to think we can develop products that are intuitive and can be used straight-out-of-the-box this is difficult to achieve. It is particularly difficult with new unfamiliar technologies and when products are introduced to new cultures and contexts. As a consequence products of any complexity require instructions.

The thesis explored the design of Pictorial Assembly Instructions (PAIs). These are an important element of products requiring assembly by the consumer as the success of the product relies on the consumer’s ability to interpret and enact the instructions correctly. However there is very little research published about PAI design, particularly with regard to the creation of effective illustrations.

The small amount of previous research into PAIs and instructional illustration used positivist reductionist approaches rather than practice based studies. Outcomes of the previous research replicated concepts already evident in practice and it was apparent that progress and development for PAI...
design was occurring in the field where designers were engaged in iterations of design informed by user trials.

The thesis focused on a project to develop PAIs for a flat pack wheelchair for developing countries designed by Motivation, a U.K.-based charity. The final users and assembly technicians would probably be unfamiliar with the wheelchairs’ construction techniques, have no formal training or exposure to the pictorial conventions of technical communication and also be illiterate.

The research started with a review of the literature on pictorial communication in developing countries. This was followed by an examination of PAIs that reflected best practice and interviews with designers from Lego and IKEA about how they develop and encode knowledge for PAI design. The findings of this stage were compiled as a list of guidelines and exemplars.

The second part of the research involved iterations of design and testing. The first trial involved designing and building a set of chairs and stools that replicated the construction methods used in the wheelchair. A set of PAIs based on the guidelines from existing best practice were produced and then trialed with subjects in Sri Lanka. This validated the effectiveness of the PAIs while also showing details that required development. Many of the conventions evident in IKEA and Lego PAIs, such as the use of line drawings, three-quarter views, and image sequences, worked well while graphic conventions such as elevation drawings, enlargements of details and iconic representations of actions were not well understood.

The outcomes of the literature review, artifact analysis, designer interviews and design practice were then used to create a pattern language for the design of PAIs. The pattern language can be found at www.paispatternlanguage.org.

PETER SCHUMACHER

Making This Edition
EQUILIBRIUM DESIGN
SYDNEY

In conceptualising the print and digital publication designs for this edition of IDEN, we interrogated the theme of ‘making’ from a number of angles through the design.

IDEATION + EXPLORATION
► We made a hand-cut ‘M’, which is the key graphic device utilised across the publication—to badge, sculpt pages and pattern.
► Given that making is at the core of a designer’s work, (including our own work as visual communicators, as we ideate, explore, prototype and produce), ‘M–W: make–work’, has been used for the identity for this edition—make it work!
► The ‘M’ in pattern form embodies the momentum that making affords, as signified in the forward arrows discovered in the counter-spaces.
► Engaging with the content for each article, we ‘made’ abstracted representations that picked up on the themes within each text, generating a tonal visual vocabulary and para-text, rather than being pure illustration.

PROTOTYPING + PRODUCING
► We made several prototypes of the physical book to make a unique artefact. The digital artefact interestingly changed from prototype to product as soon as it was approved.
► We designed the physical book such that we could collaborate with DigitalPress to exploit current best-practice for digitally printed publications using: innovative environmental paper stocks; a five ink print process, matte fuser and machine gearing to give us vibrant and crisp reproduction; specialty binding; and, a double-crash-fold poster as the dust jacket. We hand-folded these.
► The digital version of the book exploits interactive PDF features to facilitate navigation of the document and be optimised for screen.

END