The Digital Craftsman and His Tools

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Abstract

From knife to hammer to 3D printer, the influence of tools on a design is not to be underestimated. In his essay 'Tools', originally published in 2000 in a book covering the work of LettError, a collective of two Dutch typographers, Jan Middendorp (2000) argues for the importance of creating your own tools. He refers to the fact that a craftsman, the predecessor of the designer, was never completely satisfied with the tools that were sold in shops. 'They always had the tendency to personalize their tools, to appropriate them by honing them, converting them or expanding them. The more specialized the work, the greater the demand for customized or individually made instruments.' Yet for a long time the instruments of production have been closed systems, discouraging appropriation. This is now changing. Following the personal computer and a range of digital advances, the advent of the personal digital fabricator has lowered the barrier into production and provoked a revival of the idea of 'making your own things'.

Unfold started to 'customize' their 3D printer into a clay printer. The open source hardware allows them – similar to traditional craftsmen – to create their own tools. By doing so they break away from a predetermined way of designing, dictated by the existing digital tools. As such, they can thoroughly intervene in the production process, and therefore also in the eventual design.

Unfold's 3D printer for ceramics not only harnesses the potential of new technology and materials, but also projects the past history of specific techniques into the future. The printer has a great resonance with the way traditional potters handle clay, however, because of its ability to produce such fine layers, a new language of forms are made possible.

In his book 'The Craftsman', Richard Sennett states that 'In technical craftsmanship, the sense of possibility is grounded in feeling frustrated by a tool's limits or provoked by its untested possibilities.' For Unfold, these untested possibilities not only lay in the unlocking of new form-languages. With manufacturing going digital, we see a merging of aspects of the pre-industrial craft economy with high tech industrial production methods. A combination that has the potential to shift power, from industrial producers and those regulating infrastructure to the individual designer and the consumer.

This paper includes excerpts of the article 'The Electronic Artisan' by Claire Warnier and Dries Verbruggen, published in 2013 in Disegno Industriale.

The Role of the Designer

What is the role of the designer and how is it changing in a time when design and manufacturing become increasingly more digitized? This question is key to understanding the work of Belgium based design studio, Unfold. The studio, founded in 2002 by Claire Warnier and Dries Verbruggen, develops projects that investigate new ways of creating, manufacturing, financing and distributing in a changing context. A context in which we see a merging of aspects of the pre-industrial craft economy with high tech industrial production methods and digital communication networks.

The name Unfold is derived from the first project they developed collaboratively titled 'a tribute to the surface', in which a computer program, designed to unfold simple forms, was used on complex 3D models, in this case a 3D scan of their own bodies. Unfolding this digital full-body scan generates a two-dimensional pattern, which after cutting by means of computer controlled processes, is reconstructed into a series of personal jewels in various materials like silver, porcelain and leather. The resulting objects are low polygon copies of the body, giving them a nearly perfectly fitting form, truly made for the wearer.

While the Oxford English Dictionary describes 'unfold' as meaning to 'open or spread out from a folded position' the second meaning 'gradually develop or be revealed' more aptly describes the narrative nature of Unfold's work.

A Digital Potter's Studio

When entering one of Z33's[1] big white galleries, you find yourself standing in front of a long table. There are some syringes, cloths, tools and materials lying on the table, as if the table was used to prepare clay. An apron is hanging in the corner of the room. It feels as if you enter a ceramic workshop, but not an ordinary ceramic workshop. It's a digital variation of the traditional workplace. On one end of the table is a stool. When you are seated, you face an empty potter's wheel and an open frame with a green laser line. Behind the wheel the wireframe image of a revolving cylinder is projected on a screen. By crossing the laser beam with your hand, the shape of the revolving cylinder changes according to the movements of the hand. It's a potter's wheel where the material to be moulded is not physically present; a virtual potter's wheel.

Visitors of the installation are invited to *throw* their own digital pots. With the press of a button, they can

1. Z33, House for Contemporary Art, Hasselt, Belgium save their virtually shaped design in a database. The last 16 designs are projected onto the wall.

On the other end of the table, a machine transforms the digital design into matter. Thin rolls of porcelain clay are layered on a downwards moving platform. The technique is colloquially called 3D-printing. With each new layer, the clay object on the platform grows.

Halfway alongside the table there is a display cabinet, showing the 3D-printed and fired ceramic vases designed by visitors. The installation, *L'Artisan Electronique*, was developed in 2010 by Unfold, together with interaction designer and creative coder Tim Knapen for the exhibition *Design by Performance*.

Programming is Much too Important to Leave to Programmers

Unfold has long been interested into the possibilities of 3D-printing, a technology that connects to their interest in bridging the digital, screen-based world with the physical, material world.

L'Artisan Electronique was the first project that focused on the exploration of the technology, which became possible when, in 2009, they bought a building kit for a Bits-from-Bytes 3D-printer. This was the first building kit for a 3D-printer based on the open source RepRap project. Soon after the development of the RepRap, half commercial building kits came on the market, neatly containing all the necessary elements in one kit and today dozens of commercial derivatives have originated from the open source RepRap. As the machine is self-built and open source, it is accessible and hackable which encourages the user to make adaptions and adjustments. For Unfold this started to awaken their dedication to the crafting of new tools.

In his essay 'Tools', (Middendorp, 2000) published in a book covering the work of LettError, a collective of two Dutch typographers, Jan Middendorp argues for the importance of creating your own tools. He refers to the fact that an artisan, the predecessor of the designer, was never completely satisfied with the tools that were sold in shops:

> *They always had the tendency to personalize their tools, to appropriate them by honing them, converting them or expanding them. The more specialized the work, the greater the demand for customized or individually made instruments.*

For the traditional craftsman, the skills needed to create those tools where very similar to the ones needed to apply those tools in the trade. In the digital era the skills to create digital tools (coding), are vastly different from the skills needed to work with those tools. The job of producing digital design tools is thus relegated to big cooperations who produce them, which leads to a myriad of problems. Middendorp states '[p]rogramming is much too important to leave to programmers', (ibid). This is a reference to Giancarlo De Carlo's '[a]rchitecture is too important to leave to the architects' (de Carlo, Bouman and van Toorn, 2005).

Fascinated by digital tools and inspired by the artisans' view on tools, Unfold started to customize their 3D-printer into a ceramic printer. The open source hardware allowed them – similar to traditional artisans – to do so. By doing this, they broke away from a predetermined way of designing, dictated by the existing *black box* digital tools. As such, they can thoroughly intervene in the production process and therefore also in the eventual design language.

The Ceramic 3D-Printer

A RepRap 3D-printer is designed to print thermoplastics. The printing head heats the material up to its melting point and extrudes it through a narrow nozzle, after which, the material cools off and solidifies. Widely used plastics are ABS and PLA. Although these materials are interesting for making prototypes and small parts, Unfold wanted to utilize a more refined material, a material that makes the printed object an end product and not a prototype – clay.

Clay is a natural material that has been used to produce utensils for thousands of years. The fact that ceramic objects are passed on as an inheritance gives them a quality of eternity and value, which is enhanced by their fragility. Next to the more emotional connotation of the material, it also has many specific technical qualities and applications. It is heat resistant and can be heated up to more than a thousand degrees, which makes it suitable for metal or glass casting. It can also be used to insulate electrical wires or for the production of catalysts (water and air filters).

For the ceramic printhead, Unfold based itself on an open source design for a cake frosting machine. It consists of a reservoir for the clay that is connected to an air compressor. The pressure on the reservoir produces a constant flow of clay paste that can be switched by an electronic valve. This way, the shape is formed layer-by-layer, similarly to plastic objects, but without heating the material. After printing, the object is treated similar as other objects formed from clay: bisque fire, glazing and then a second glaze fire.

The extrusion technique that the printer uses is very similar to a technique used in traditional pottery and one of the very first techniques humankind used to create utensils – coiling. The coiling technique consists of building up separate rolls of clay until a solid form is reached. Suddenly this technological application came very close to an age-old craft. Due to this technical similarity, the printing of clay became a logical step in a search for innovation but with respect for traditional crafts methods and their inherent qualities.

All the development and print head designs are shared on a blog[2] under Creative Commons license, with the hope that others improve the designs or find meaningful new applications for them. By open sourcing the development process one can create a large pool of talent to work on it, something which used to be virtually impossible for a small design studio thirty years ago.

2. unfoldfab. blogspot.com

Artefacts of a New History

Herbert Read, stated in 1936 that '[t]he real problem is not to adapt machine production to the aesthetics of handicraft, but to think out new aesthetic standards for new methods of production' (McCullough, 1998). While valid, this statement contradicts with what is presented in *L'Artisan Électronique* where handicraft analogies are translated into their digital counterparts. But the vases created on the virtual potters wheel should be seen as props in the larger narrative of a museum installation and not as the end goal for the ceramic 3D printing process. Like Read argues, the full potential of a new process can only be discovered through rigorous experimentation and listening to what the tool wants to make. This also resonates with Brancusi's statement: 'You cannot make what you want to make, but what the material permits you to make' (cited in, Pallasmaa, 2009).

Artefacts of a New History was a research project into the intrinsic qualities of the extrusion based ceramic 3D printing process. Early on it was observed that traditional thin walled objects like the vases from *L'Artisan Électronique* pose a challenge during printing due to the use of soft and slow drying clay and the resulting plasticity of the object while being printed. This often leads to objects collapsing under their own weight during printing. Resembling the idea of the buttresses used in gothic architecture, lighter and stronger structures can be created by integrating a scaffolding into the design of the object itself. Instead of building objects out of thin and unstable walls, they can be printed using complex geometric structures. These types of structures would be very difficult to obtain with traditional ceramic processes, but as Cornell University researcher Hod Lipson states, in his book, *Fabricated: The New World of 3D Printing*, one of the ten underlying principles fundamental to 3D printing is 'manufacturing complexity is free.' As opposed to traditional manufacturing processes, where extra complexity requires a more complicated and expensive mold, there is no penalty with 3D printing when an object is made more complex (Warnier, et. al., 2014).

When trying to design these intricate structures for printing in ceramics, Unfold stumbled upon the limitations of the current crop of design tools intended for the 3D printing process.

The G-Code Stacker software, developed together again with Tim Knapen, arose out of this frustration to not have full control on the production process. Middendorp refers in this context to the tool horizon (Middendorp, 2000). It is a typical burden of designers in the digital era: a digital design program is imposed upon designers as if it were a preset straitjacket. Digital programs provide enormous possibilities, but they are never endless. Many designers are not aware that these programs limit their creativity. Once a designer is confronted with the limitations within the program they are working with, they don't have the possibility to go beyond the borders of the program, not only because these applications are closed source, but also because the skills needed to code them are very different from the traditional designer skills. Because the same tools are used over and over again, the same tool marks are left and the variation in design language becomes sparse.

The G-Code Stacker enables you to design intricate 3D geometries and structures. The software allows you to design much closer to the 3D-printing technique used in RepRap derived 3D printers called FFF (Fused Filament Fabrication). Objects are constructed by extruding lines of plastic (or clay) that trace the outlines of the object filled in with a hatched pattern. This is similar to a 2d plotting machine, but by stacking these 2d layers one gets a 3D object. The standard software that converts your 3D geometry to these toolpaths is called a slicer. The slicer gives you very limited control over the way these paths are drawn.

The G-Code Stacker allows you to control the toolpath and to design an object on a layer-by-layer level close to the process. Mark Ganter of the University of Washington, described the Gcode Stacker in the blog Open3DP:

> *While it sounds like a crazy idea to engineers (perhaps a step backwards), it makes real sense for cutting edge design (it's about control). The current crop of G- code generator systems (including commercial code) don't provide much in the way of graphical G- code editing tools. Further, G-code generators really don't like objects which are one extrusion band thick. Thus the idea has some real merit.* (Ganter, 2012)

Using the combination of the ceramic 3D printing process and the tool path design tool, Unfold was able to develop a new language in ceramics. The results can be seen in projects like The Peddler, a collaboration with the french craft perfumer Barnabé Fillion for which Unfold created a set of objects that resemble alchemical tools and utensils. The three diffusers and different receptacles, both produced using the ceramic 3D print process and the small machine, invite people to be involved in the process, putting a real emphasis on the ritual and the experience of perfume.[3] After dilution the perfume is poured in the central core of the diffuser where it is completely absorbed in the porous ceramic material. These diffusers have intricate shapes inspired by botanical drawings that contain many small compartments around the core, this geometry creates a lot of surface area from which the volatile fragrance molecules can slowly evaporate. A project using virtually the same parameters, but on the other end of the high street/main street (or no street) spectrum, is the ongoing research into the development of open-source water filters for developing countries where the extra surface area could potentially make better performing filters.

Stratigraphic Manufactury

In his book, *Abstracting Craft*, Malcolm McCullough

3. www.unfold.be/pages/projects/items/the-peddler-barnabé-fillion tries to peel away the layers of connotations that the term 'craft' has accumulated over the years, in order to get to the core of what craft actually is. By abstracting 'craft', McCullough aims to find a place for digital tools, techniques and concepts in the realm of craft.

> *The work of craft is neither the design nor the individual artifact: it is the tradition of the very production. It is the presence of many objects identical in their conception, and interchangeable in their use, but unique in their execution ... Craft implies working at a personal scale, acting locally in reaction to anonymous, globalised industrial production.* (McCullough, 1998)

By zooming out from the level of the artifact, or the hand of the maker, and placing more attention on the wider context of crafts, McCullough opens up the possibility from using machines and methods reclaimed from industrialism in craft.

In *Stratigraphic Manufactury*, Unfold explores methods of manufacturing and distributing design in the dawning era of digital production. *Stratigraphic Manufactury* is a new model for the distribution and digital manufacturing of porcelain, which includes local small manufacturing units that are globally connected. One that embraces local production variations and influences.[4] The installation was commissioned for the inaugural Istanbul Design Biennial by Joseph Grima, curator of the Adhocracy exhibition and former editor in chief of *Domus Magazine*.

A set of digital 3D files of simple designs was emailed to a network of people around the world who had already acquired the ceramic 3D printing process that Unfold had developed and documented for others to use. The instruction was not to alter anything in the digital design but to be free to incorporate personal and local influences during the actual production process. This freedom ranged from simple aspects like the type of clays used for printing (which influences shrinkage and thus the final size) but also which glaze was used and where and how it was applied, or at what resolution the digital 3D file was converted to tool-paths. These copies were presented in the exhibition as part of a local manufacturing shop. Two Turkish ceramists, Mustafa Canyurt and Ahmet Gülkokan, ran the Istanbul production in the exhibition and printed more localized sets of *Stratigraphic Manufactury* tableware. Similar setups and collaborations have been presented in New York, London and Taiwan.

Distributed manufacturing is not a new concept. In industry the term can be used to describe a manufacturing system in which the various parts and subsystems of a complex product, like a car, are produced in different locations around the globe and shipped through a supply chain to a single place for final assembly. After this, the final product is shipped around the world again for consumption. The one exception where the term is understood differently is the chemical industry where, due to the cost and risk of shipping chemical substances, manufacturing happens on a small scale as close as possible to the end user (Chrisman, 2010). In the maker context, distributed manufacturing is defined more along the lines of the later example. Small-scale local manufacturing units (think home, small workshops or service centers) are connected to the network which facilitates the exchange of blueprints in digital format. Those digital blueprints drive digital manufacturing tools like CNC routers or 3D-printers. In this scenario, it is the information which is shipped around instead of actual parts.

Often there is the desire to have the exact same output no matter where the part is produced, by using the same materials and machines. For Unfold, the added value lies in allowing the local context and the hand of the maker in the final output. The ceramic 3D print process is still a very hands-on method where skill and experience matter. Clay needs to be meticulously prepared and loaded inside large syringes; material flow needs to be guarded and adjusted during printing. Printed wares need to be finished, glazed and fired. Even when using the exact same machine and material, the output of one maker would be different than the output of another and this should be welcomed.

For a native english reader the title *Stratigraphic Manufactury* might be oddly spelled. This misspelling is intentional as if it resembles a word that exists in other languages like Dutch, Ggerman or French (but not in English) and which is, like manufactory, derived from the Latin 'manu facere' but with a different meaning. The meaning of the Dutch word 'manufactuur', is more closely related to the original Latin 'manu facere' meaning 'produced by hand'. The 'manufactuur' was in essence a pre-industrial scaled up version of the craft studio or cottage industry with low mechanization and limited division of labour. The advent of the industrial revolution brought a split of the 'manus' and 'facere', of hand and production and ultimately, of making and manufacturing. McCullough argues that one of the important reasons for this is because 'the means of production had become too elaborate, too extensive, and too centralized to be owned and operated by an independent craftsman' (McCullough, 1998).

With manufacturing going digital we can reverse the industrial revolution's blow against artisans by taking industry and bringing it back to the scale of a studio. Ultimately, it is a merging of aspects of the preindustrial craft economy with high tech industrial production tools and digital communication networks. A combination that has the potential to shift power, from industrial producers and those regulating infrastructure to the individual designer and the consumer.

The conference title ends with a question mark: 'All Makers Now?' Are we all makers now? We've probably never stopped being makers, we've only stopped being manufacturers. Today, we can all be manufacturers again.

4. www.unfold.be/pages/projects/items/stratigraphic-manufactury

THEME: MATERIALITY & AESTHETICS

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